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A CLOUD CLIMATOLOGY FOR SELECTED ANTARCTIC LOCATIONS FROM NOVEMBER 1966, DECEMBER 1966 AND JANUARY 1967 - METEOROLOGICAL SATELLITE DATA

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July 1967

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A CLOUD CLIMATOLOGY
FOR SELECTED ANTARCTIC LOCATIONS
from
November 1966, December 1966 and January 1967
Meteorological Satellite Data

by

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1. INTRODUCTION

1.1 Purpose

This report has been prepared in response to a requirement for a planning study on the suitability as temporary base camps of three selected locations along the Byrd Land and Ellsworth Land Coasts. These three temporary camps are Byrd Camp Number One, located in the Edsel Ford Range (approximately 77° S., 144° W.), and the proposed Byrd Camps Numbers Two and Three (planned locations 75° S., 121° W. and 73°45' S., 99° W., respectively).

These camps are to be operated during the resupply period from November 1967 through January 1968 for comprehensive surveys in several scientific disciplines. Camp support will depend on ski-equipped LC-130 aircraft operating from Byrd and McMurdo for resupply. VH-1D helicopters will be utilized to conduct the actual surveys.

Flight operations at Byrd Camp Number One were seriously handicapped because of "whiteout" (appendix A) during much of the 1966-67 operating season. Accordingly, so as to better assess the whiteout probability during the summer operating season at all three camp locations, and therefore their suitability as survey base camps, a detailed study was requested of cloud conditions as revealed by meteorological satellite data.

1.2 Discussion

Available meteorological satellite data for the summer-operating season and that portion of West Antarctica in which these camps are located consists of ESSA-III AVCS photographs, obtained from the National Environmental Satellite Center and the National Weather Records Center, and ESSA-II and NIMBUS-II APT

pictures copied at McMurdo Station, all for the period November 1966 through January 1967. The satellite AVCS photographs and APT pictures were evaluated for total sky cover, and for cloud type and amount; and a nephanalysis was then drawn for each day of this 3-month period. Surface and upper-air charts prepared at McMurdo Station were compared with the satellite cloud and weather systems, and reanalyzed as necessary. All available surface, upper-air and aircraft weather observations for the period and area under study were used to evaluate and validate the satellite data. Table 1.1 provides a summary of the satellite and conventional meteorological observations used in this study.

The quality of the APT pictures was generally adequate for determining general cloud features for the area in which Byrd Camps Nos. 1, 2 and 3 are located. However, for purposes of this study, reliance was almost entirely placed upon the greater detail offered by the AVCS photographs.

Place names used in this study are as indicated on the figures contained herein, rather than such more precise delineations for these appellations as may be geographically proper.

Table 1.1. Number Of Satellite and Observational Data

PHOTOGRAPHS	NOV.	DEC.	JAN.
ESSA III AVCS	229	208	186
NIMBUS II & ESSA II APT	Approx. 150 used for entire period		

NUMBER OF AVCS/APT PICTURES OF --		NOV.		DEC.		JAN.	
		APT	AVCS	APT	AVCS	APT	AVCS
	BYRD	15	138	30	142	40	120
	CAMP # 1	10	116	30	131	25	120
	CAMP # 2	0	127	0	133	0	114
	CAMP # 3	0	107	0	118	0	97

NUMBER OF WEATHER OBSERVATIONS AVAILABLE FOR --		NOV	DEC.	JAN.
	BYRD	358	325	261
	CAMP # 1	244	256	204
	NGD-32	17	62	0
	AIRCRAFT	94	93	105

2. APPEARANCE OF CLOUDS IN SATELLITE PHOTOGRAPHS

2.1 General Analytical Procedure

The first steps in interpreting the ESSA-II AVCS photographs were to determine the total cloud cover in tenths, and then to identify the general cloud forms and amount. The specific cloud types were then identified when possible. Next, nephanalyses were prepared, and the desired cloudiness data were obtained from these by summation according to month and camp.

Cloud forms could be ascertained with reasonable reliability, but the satellite camera systems are not of sufficient resolution to permit detection of the small-scale details necessary for assured identification and classification by cloud types. The resolution of ESSA-III AVCS photographs varies from approximately 3/4 miles at the center of a picture to 3 miles at the perimeter.

2.2 Distinguishing Clouds from Ice and Snow.

The albedo of clouds is close to that of snow and ice, approximately 60% to 70%. Hence, over extensive areas of snow and ice it is often difficult to distinguish clouds from the equally white background. This lack of contrast is one of the more difficult problems in the interpretation of Antarctic satellite photographs.

The satellite photographs were gridded, but sufficient topographic features were generally available to locate the areas under study as well as to serve as a guide for recognizing the existence of clouds. Snow-covered ground appears as a pattern of landmarks, and together with sea-ice and shelf-ice patterns forms a background for the ever-changing cloud features. Where the ground patterns were recognizable, it was possible to detect the presence of clouds by the obscuration of

these landmark patterns. When the sun angle was low, abrupt cloud edges and cumuliform cloud elements produced shadows which were easily detectable. The apparent width of the shadow depends on both sun angle and the viewing angle of the satellite relative to the sun. Shadows less than three miles wide were difficult to identify because of camera resolution. The shadows were most easily detected on undercasts of lower cloud, snow-covered ground and ice-covered ocean areas.

Studies of sea-ice conditions utilizing meteorological satellite photographs in comparison with aerial reconnaissance reports [2] indicate that satellite photographs do not show sea ice less than 15 cm. thick, and that sea ice 15-30 cm. thick must be closely packed before it will be seen on the satellite photographs. Even sea ice greater than 30 cm. in thickness must be of at least 60 percent coverage before it will appear on the satellite photograhs.

2.3 Nephanalyses

A nephanalysis was produced for each day of the three-month study period, to provide a numerical cloudiness estimate and thereby facilitate summation of these data. The customary nephanalysis symbology and categories as defined in appendix B were used in these analyses. In summing cloudiness from the individual daily nephanalyses, appendices C, D and E, the nephanalysis categories of O (open), MOP (mostly open), MCO (mostly covered) and C (covered) were converted to the conventional climatological categories of Clear, Party Cloud and Cloudy for user convenience. This conversion was accomplished as follows:

Nephanalysis		Cloud Climatology
Open (≤ 0.2)	....	Clear (≤ 0.3)
Mostly Open (0.21 to 0.50)	}	Partly cloudy (0.31 to 0.79)
Mostly Covered (0.51 to 0.79)		
Covered (≥ 0.8)	....	Cloudy (≥ 0.8)

2.4 Vortex Tracks

Individual vortex tracks were determined from the vortex cloud forms appearing on the daily nephanalyses, and these were compiled for each month of the study period into primary, secondary and mean vortex tracks over West Antarctica.

3. CLOUD COVER

3.1 General

A reasonable picture of mean summer cloud conditions over the southern ocean is provided by the analysis of January ship reports from the years 1920 through 1955 presented in figure 3.1 [7]. The cloudiest areas of the ocean are found in the Weddell Sea, the Bellingshausen and Amundsen Seas and the regions north of Wilkes Land. The average cloudiness of 7.5 eighths indicates that during January these areas are almost continuously overcast.

Average seasonal cloud cover over the Antarctic Continent as revealed by an analysis of weather reports during the four mid-seasonal months of 1958 is shown in figure 3.2 [3]. The cloudiness decreased inland during all seasons, from a maximum of 6 eighths along the coast to a minimum of 1 - 3 eighths over the eastern plateau. In the specific area of concern (indicated by stars), as opposed to the continent as a whole, fall (April) would appear to be the cloudiest season and winter (July), the clearest. The difference between spring (October) and summer (January) seems so slight as to be insignificant, but the pattern of the isonephs suggests that (to the extent October and January 1958 were representative months) some slight improvement is likely from spring to summer.

Variations in coastal cloudiness are strongly associated with the low-pressure systems which transit the area. Cloudiness will be at a maximum in the on-shore (northerly) winds which precede those systems. The west side

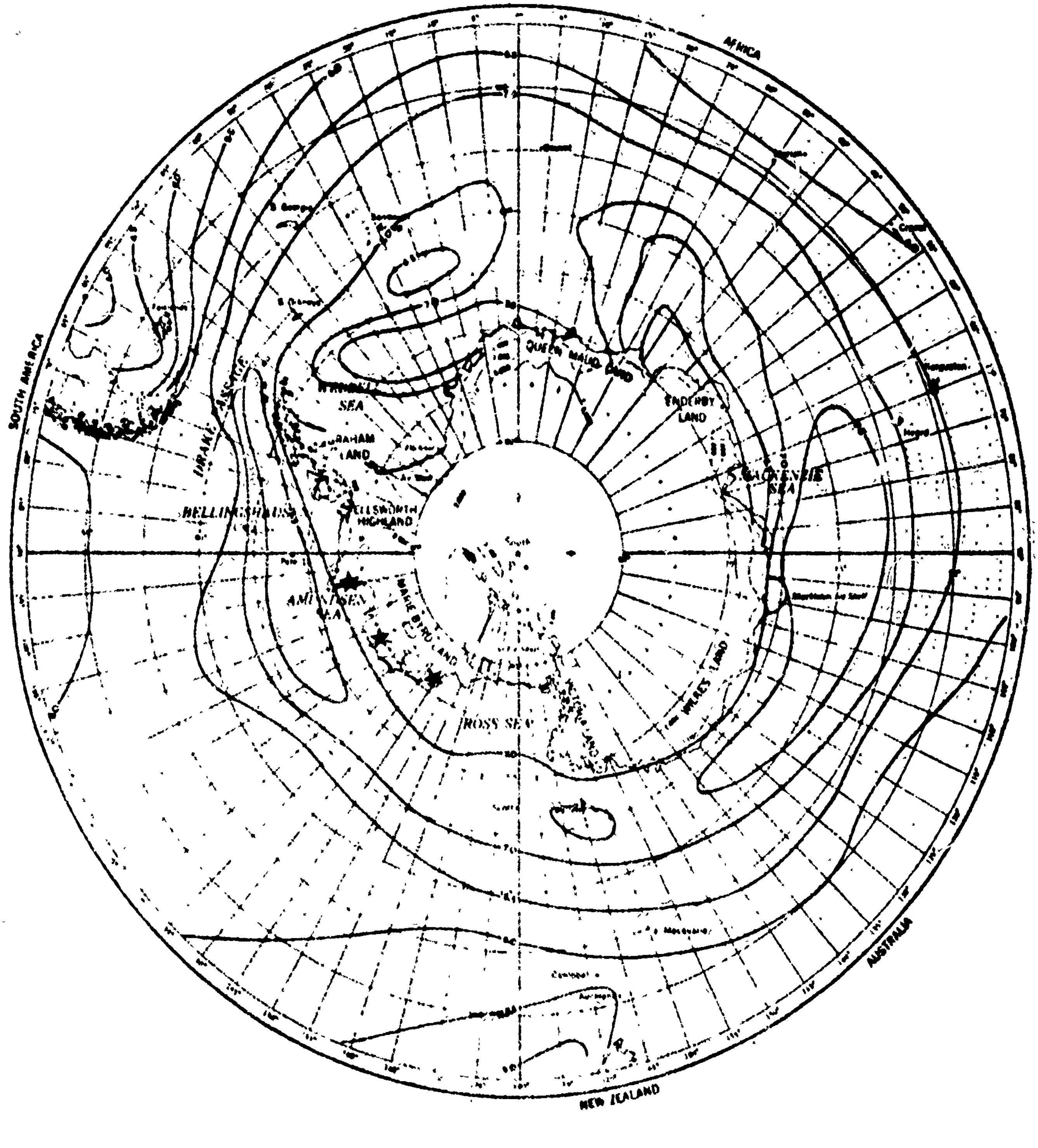

Figure 3.1. Mean Cloud Amounts (Eights) for January. [7].

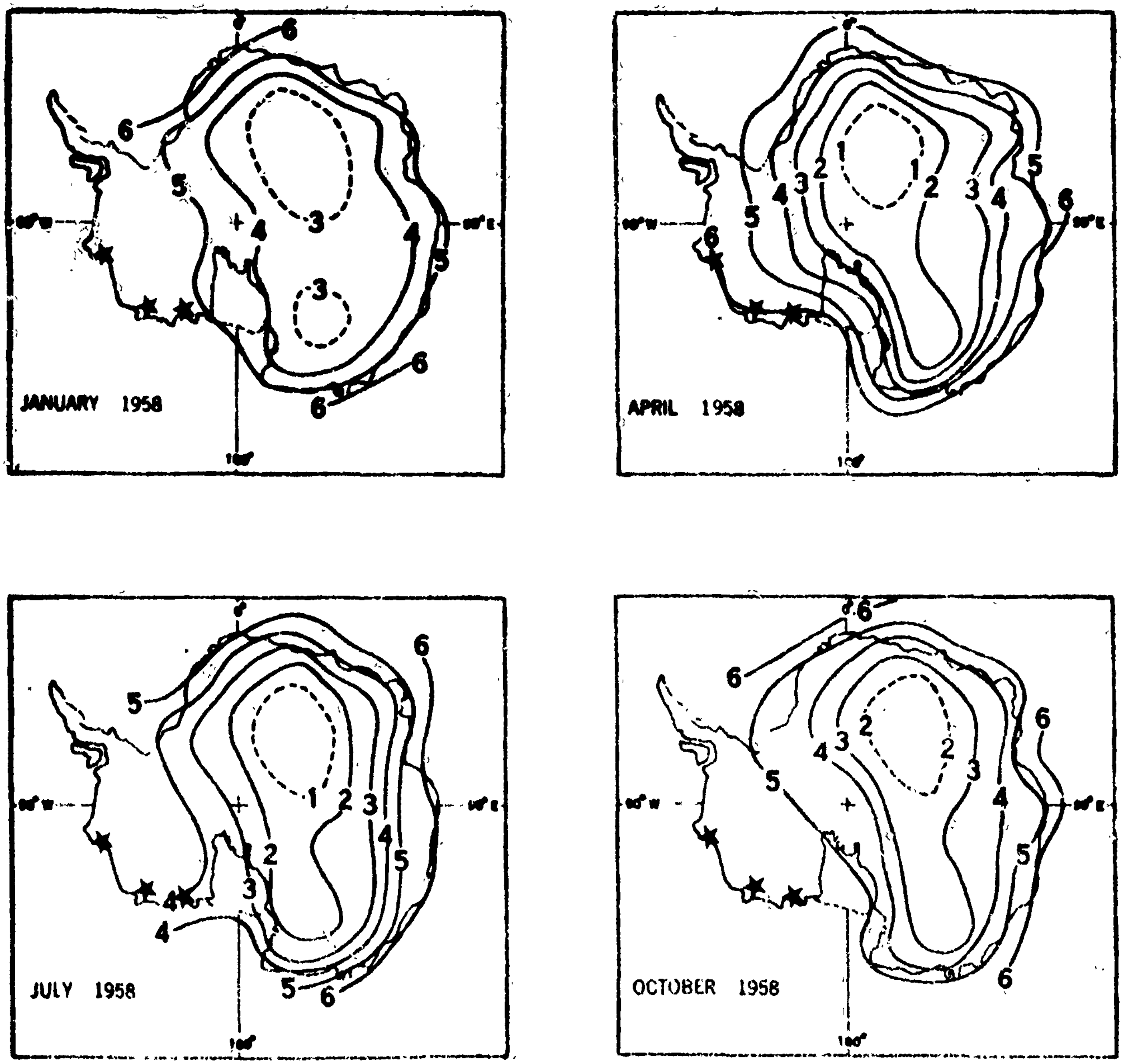

Figure 3.2. Isopleths of the Average Amount (in Eighths) of Total Cloud Cover Over the Antarctic Continent in January, April, July, October 1958. [3].

of these lows are usually regions of minimum cloudiness, due to downslope motion of the cold, dry, low-level air outward from the continent and the tendency for upper clouds to clear following a storm's passage.

3.2 Circulation Features

The most prominent features of the summer surface-pressure pattern over West Antarctica are a high-pressure ridge extending from eastern Ellsworth Land northeastward along the Antarctic Peninsula, and the W-E low-pressure trough at about 70° S. from Ross Sea to Bellingshausen Sea (fig. 3.3) [5]. The mean storm tracks for November, December and January [4] are shown in figures 3.4, 3.5 and 3.6, respectively. The correspondence between these tracks, the pressure pattern shown in figure 3.3, and the axes of maximum cloudiness in figures 3.1 and 3.2 will be quite evident.

As would be expected from an inspection of the terrain, storms are far more likely to penetrate West Antarctica than they are East Antarctica. Figures 3.4, 3.5 and 3.6 indicate, that, in the mean, storm tracks enter the Byrd and Ellsworth Land coasts during all of the summer operating-season months; but, whereas a primary storm track enters Byrd Land in November, figures 3.5 and 3.6 show only secondary tracks in December and January. The lesser cyclonic activity of these latter months tends to support the deduction noted in section 3.1, that cloudiness should improve slightly from November to January. Although different in detail, the vortex tracks prepared during this study (figs. 3.7, 3.8, and 3.9) also indicate a primary track crossing the area during November,

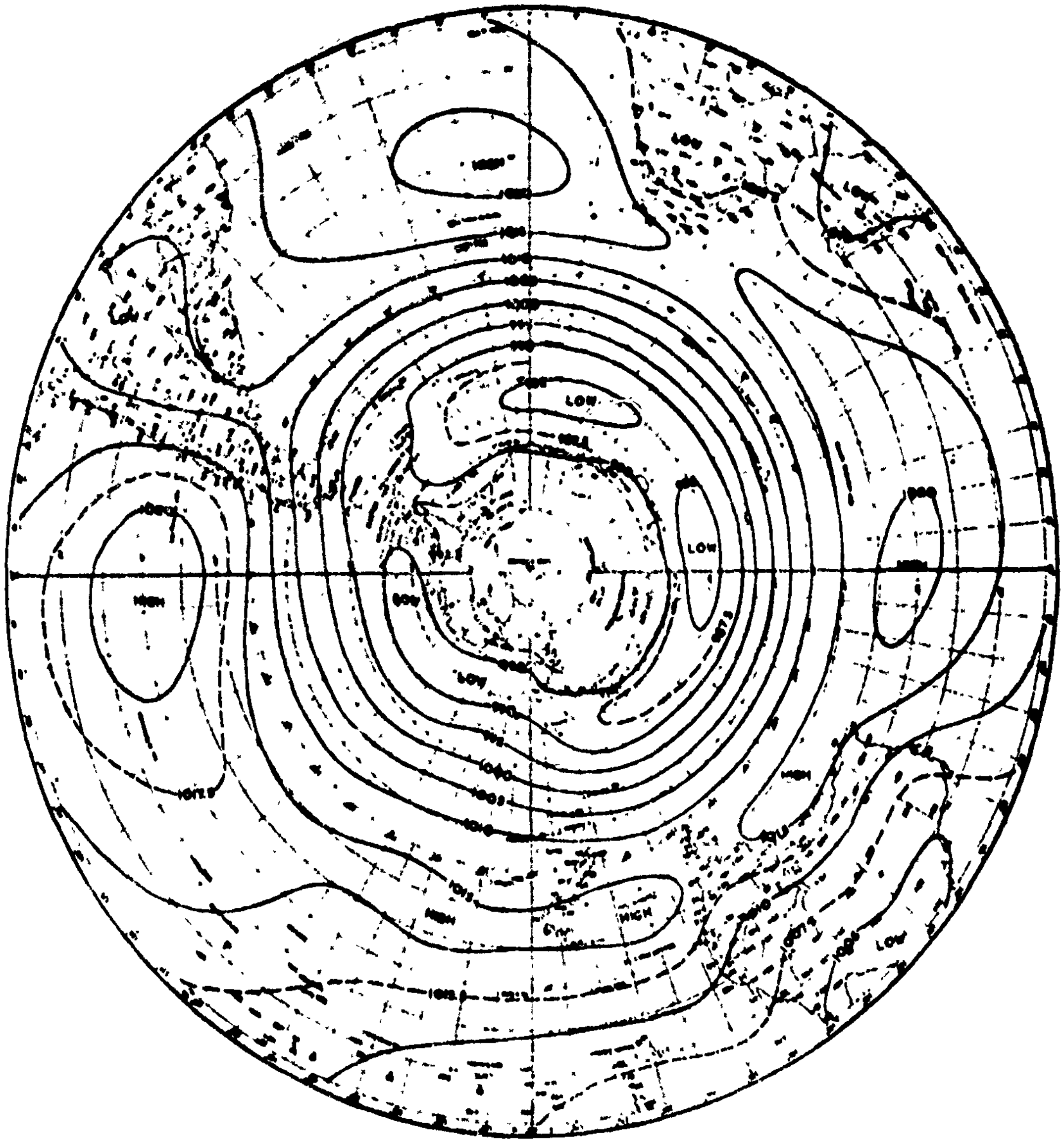

Figure 3.3. January Mean Sea-Level Chart (mb.) of the Southern Hemisphere South of 15° S. [5].

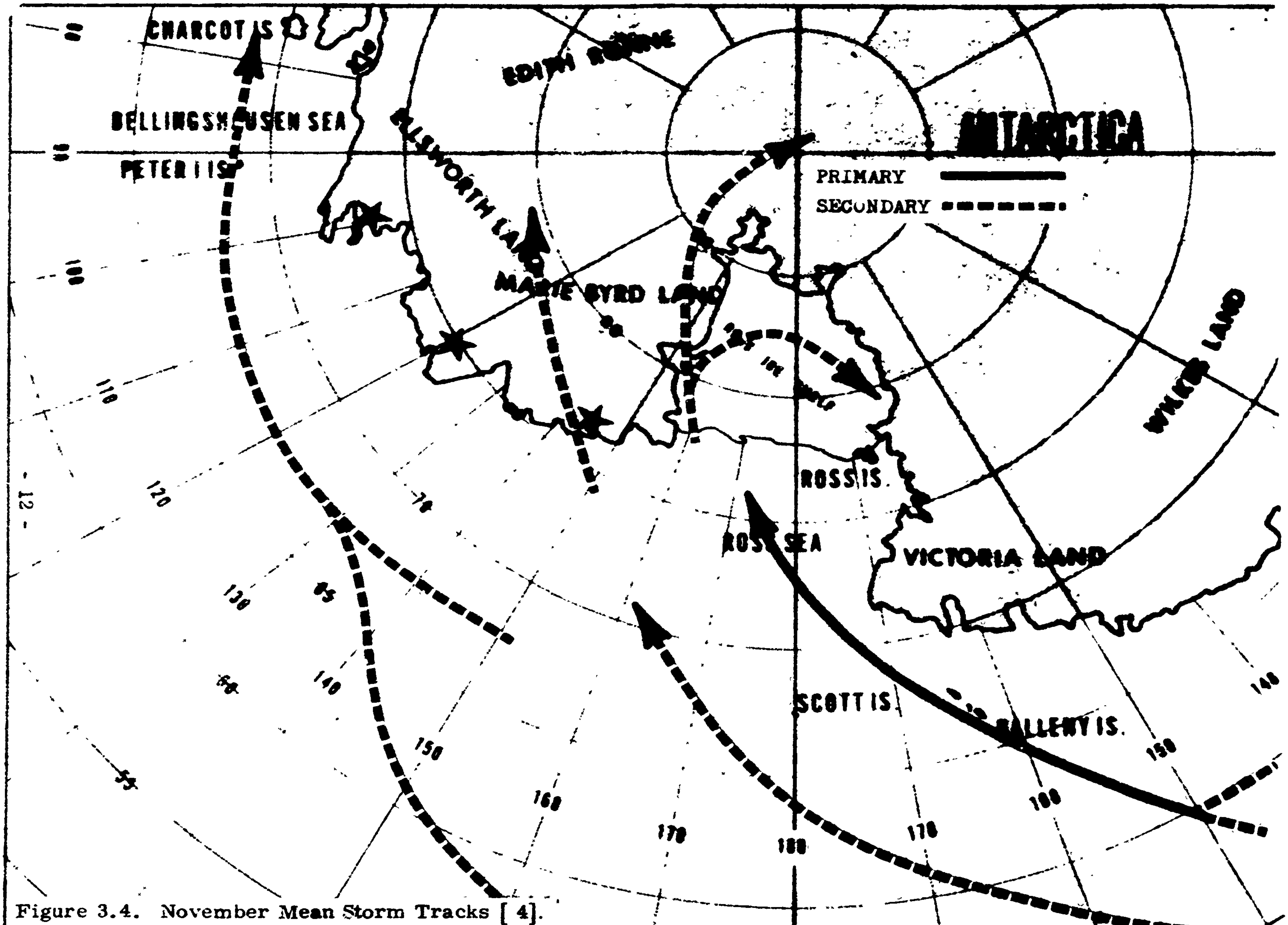

Figure 3.4. November Mean Storm Tracks [4].

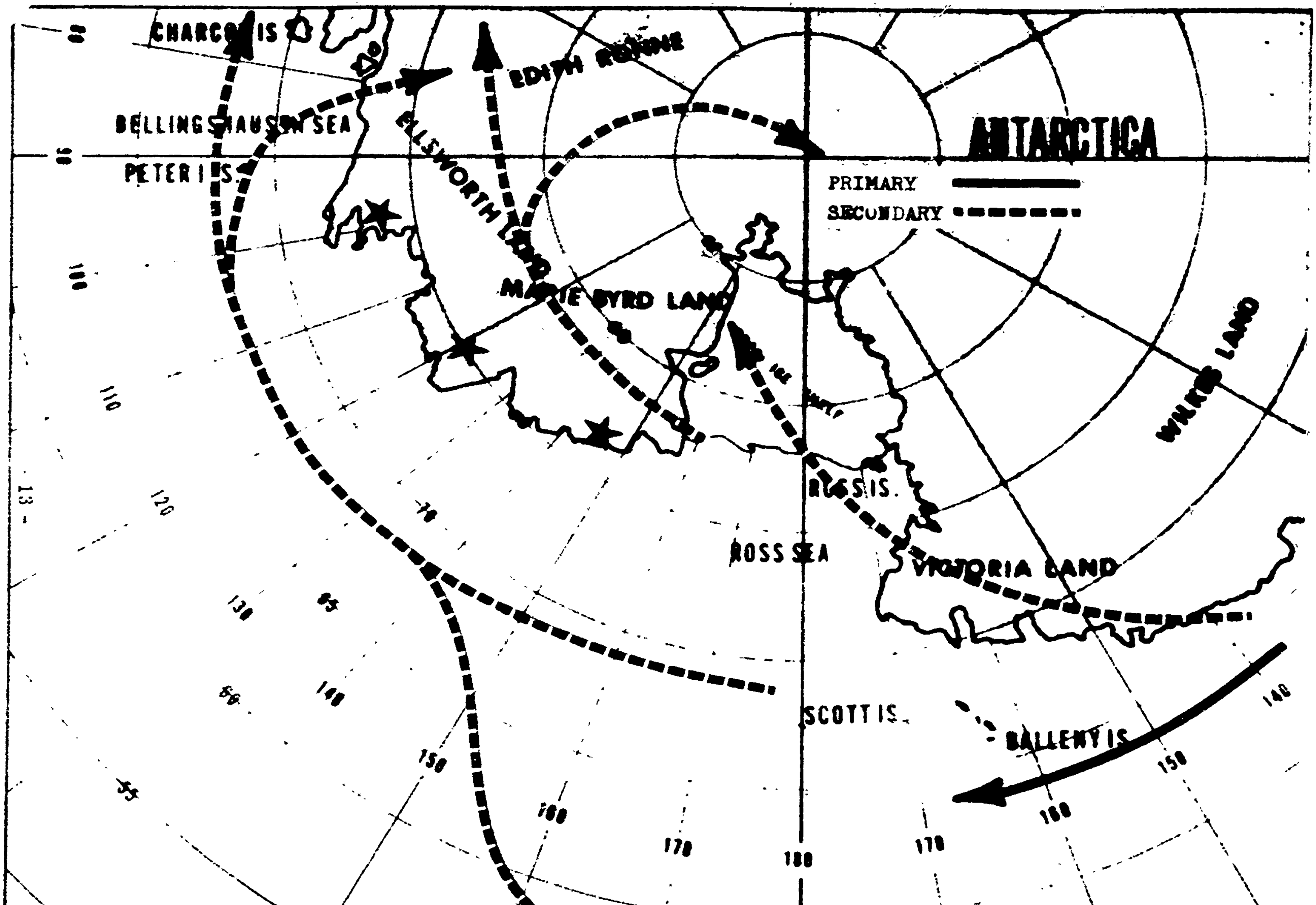

Figure 3.5. December Mean Storm Tracks [4].

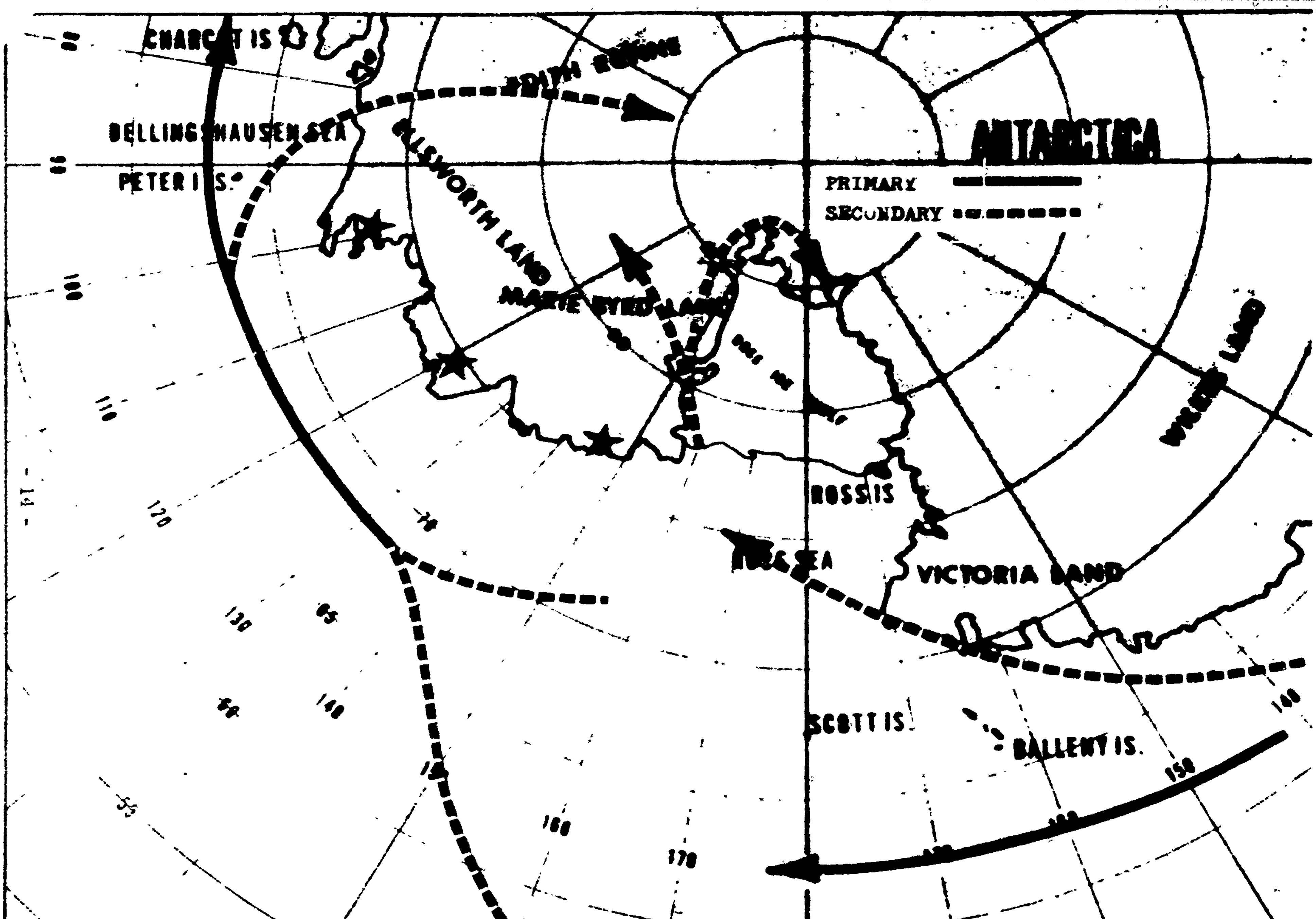

Figure 3.6. January Mean Storm Tracks [4].

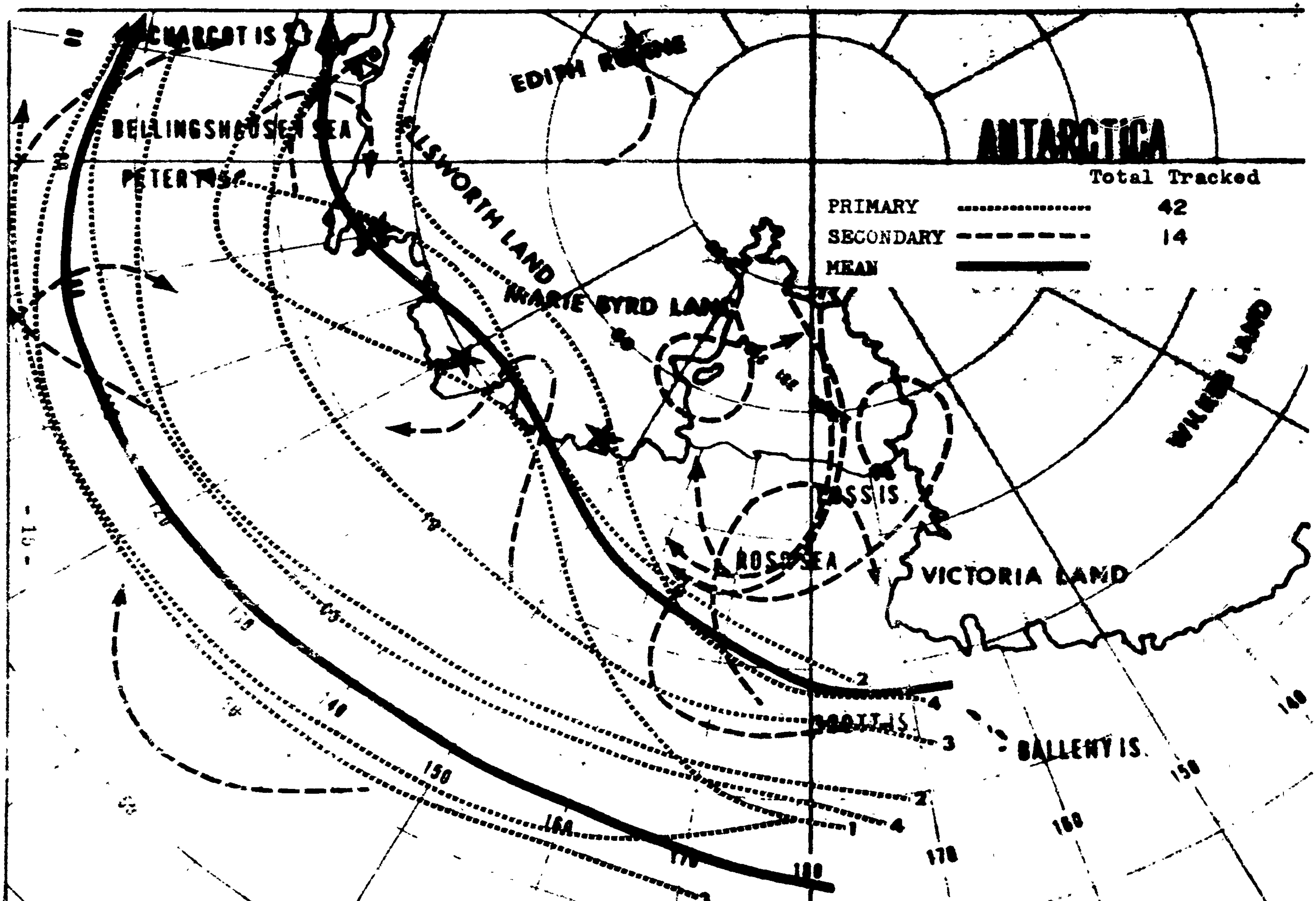

Figure 3.7. Mean Nove mber 1966 Vortex Tracks Derived from Satellite Data.

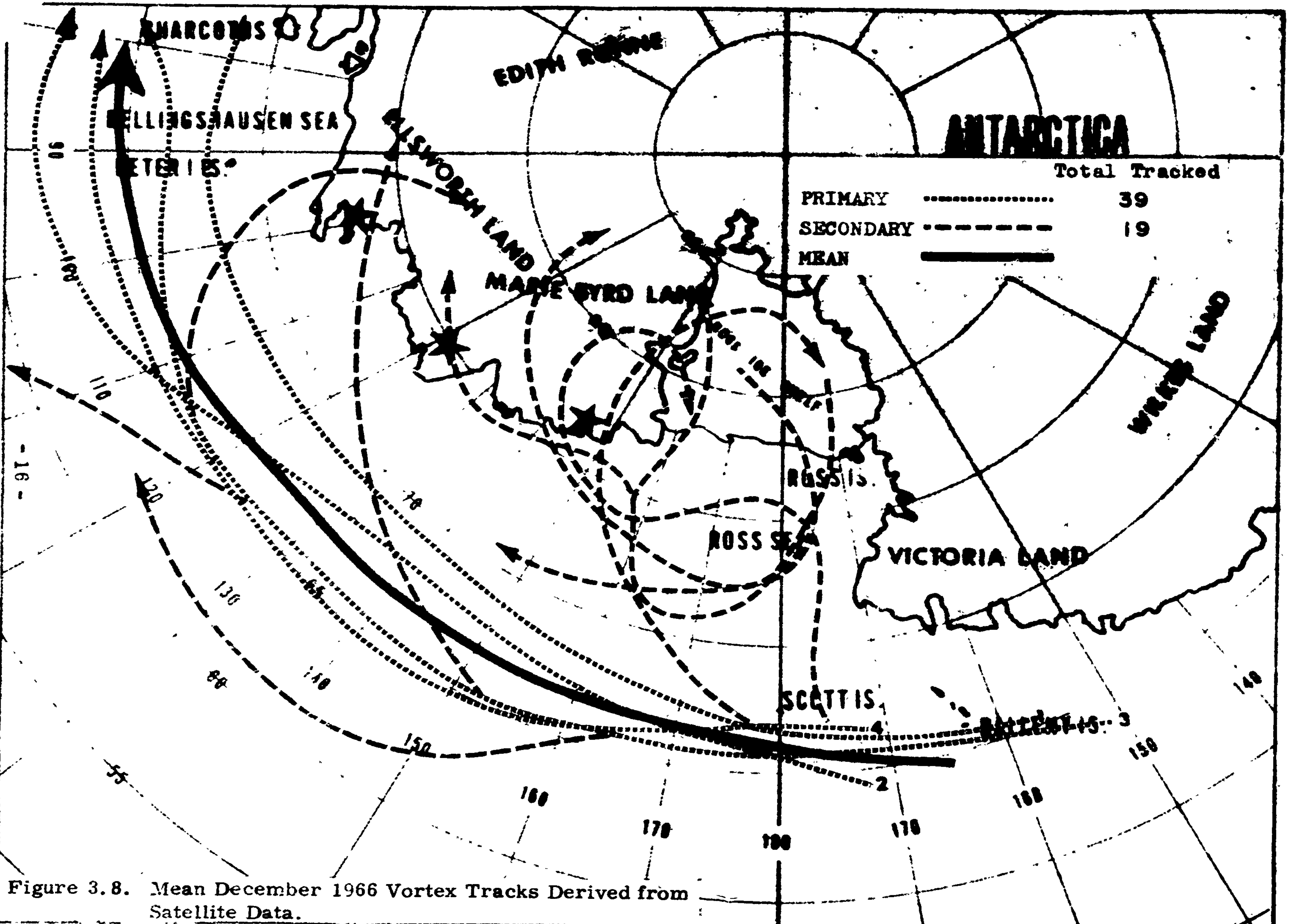

Figure 3.8. Mean December 1966 Vortex Tracks Derived from Satellite Data.

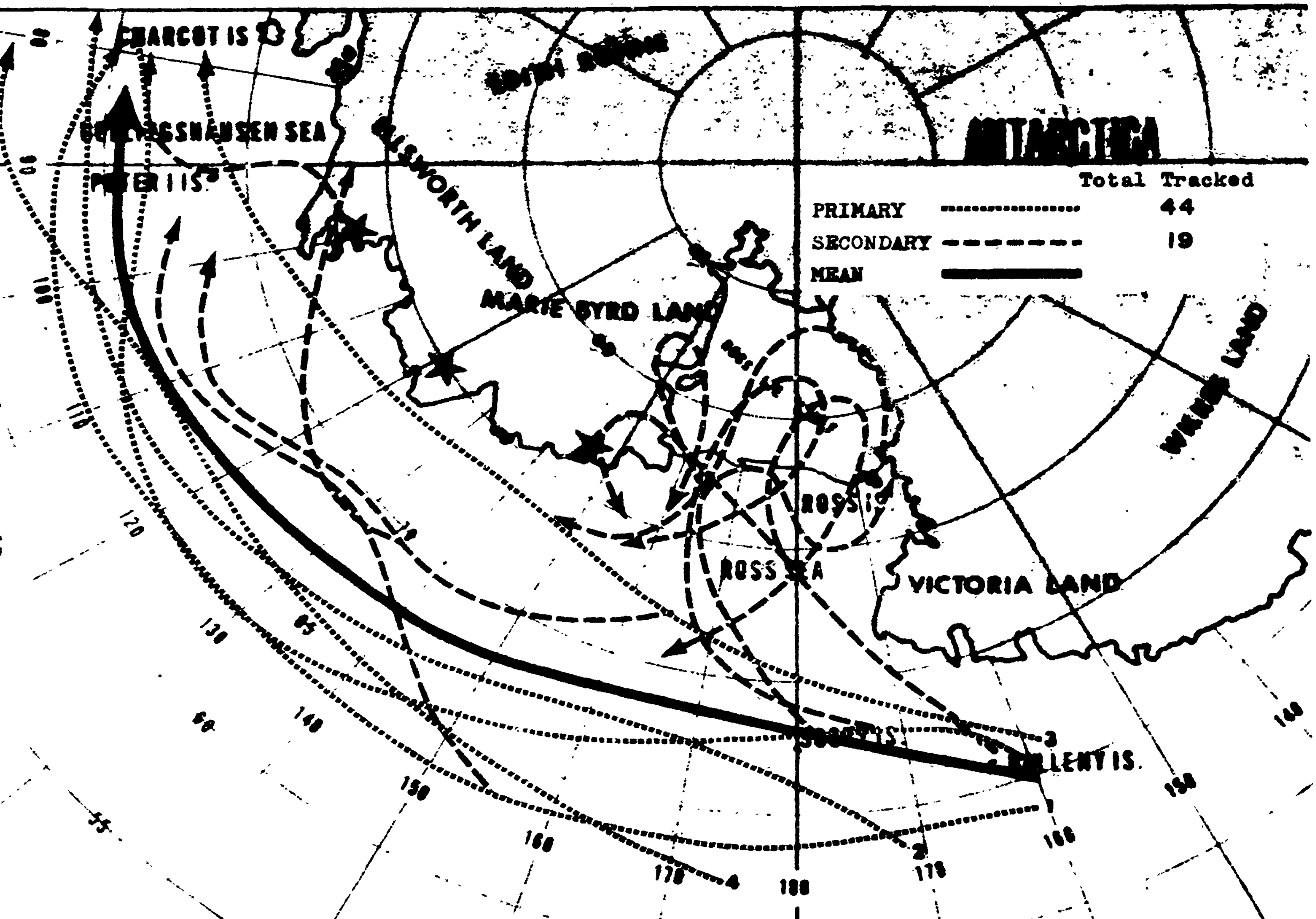

Figure 3.9. Mean January 1967 Vortex Tracks Derived from Satellite Data.

with only secondary tracks influencing the Byrd and Ellsworth Land coasts during the summer months.

Of the many maritime lows that circle the coast of West Antarctica from west to east, a large number tend to become quasi-stationary in the Ross-Amundsen Seas area. As might be expected in such situations, a widespread area of overcast skies will persist in the vicinity of the low and eastward to the ridge near the Antarctic Peninsula. A study of ice accumulation and the tropospheric circulation over West Antarctica during 1957-58 [6] indicates that in situations in which snow and ice are being accumulated the entire area is affected at the same time by a large storm. The satellite photographs examined in this study indicated also that the cloud systems associated with a major low in the Ross Sea, as well as several deep lows transiting the area, covered much of the coastal and inland regions of West Antarctica.

The coastal highlands of West Antarctica produce considerable lift in on-shore winds; hence, along the coasts with the approach of a low, cloudiness and precipitation will exceed that which might have occurred due to the storm itself.

3.3 November 1966

As shown in table 3.1, Byrd Camps One, Two and Three experienced 1 to 2 clear days, 5 to 6 partly cloudy days and 22 to 24 cloudy days in November. A late spring month, this was the cloudiest of the three months studied -- having 2 to 3 times as many cloudy days as January. The clear and partly cloudy days appear toward the end of the month; and in the case of Camps Numbers Two and Three, there is a gradual transition from predominantly cloudy to partly cloudy

Table 3.1. November 1966 Sky Cover for Selected Locations

	CAMP #1 (Clear 1, Ptly Cldy 5, Cldy 24)	CAMP #2 (Clear 2, Ptly Cldy 6, Cldy 22)	CAMP #3 (Clear 1, Ptly Cldy 6, Cldy 23)
1	Cldy	Cldy	Cldy
2	Cldy	Cldy	Cldy
3	Cldy	Cldy	Cldy
4	Cldy	Cldy	Cldy
5	Cldy	Cldy	Cldy
6	Cldy	Cldy	Cldy
7	Cldy	Cldy	Cldy
8	Cldy	Cldy	Cldy
9	Cldy	Ptly Cldy	Cldy
10	Cldy	Cldy	Cldy
11	Cldy	Cldy	Ptly Cldy
12	Cldy	Cldy	Cldy
13	Cldy	Cldy	Cldy
14	Ptly Cldy	Cldy	Cldy
15	Cldy	Cldy	Cldy
16	Cldy	Cldy	Ptly Cldy
17	Cldy	Cldy	Cldy
18	Ptly Cldy	Ptly Cldy	Cldy
19	Ptly Cldy	Cldy	Cldy
20	Ptly Cldy	Cldy	Cldy
21	Cldy	Cldy	Cldy
22	Ptly Cldy	Ptly Cldy	Cldy
23	Clear	Clear	Ptly Cldy
24	Cldy	Ptly Cldy	Cldy
25	Cldy	Cldy	Cldy
26	Cldy	Cldy	Cldy
27	Cldy	Ptly Cldy	Ptly Cldy
28	Cldy	Clear	Ptly Cldy
29	Cldy	Cldy	Clear
30	Cldy	Ptly Cldy	Ptly Cldy

skies.

The major vortex track is located at approximately 63° S. (fig. 3.7), in general agreement with the average storm track for the month (fig. 3.4). There is also a second mean vortex track across the Byrd and Ellsworth Land coasts at about 75° S. which reflects the sizable number of primary vortices which passed through that area during this month only. It may be noted from the daily nephanalyses (appendix C), that the cloudiness associated with these latter vortices affected all three camp locations to approximately the same degree. Many vortices originated in and transited the Ross Sea, including both the primaries which continued eastward and a number of secondaries which remained in the Ross Sea area. Albeit the more southerly mean vortex track appears better developed than the primary storm track shown across the Ross Sea and into Byrd Land in figure 3.4, it is difficult to conclude from this indication whether November 1966 was significantly cloudier than normal for this time of year. On several days, as may be seen from appendix C, large operating areas in the vicinity were clear when the camps themselves were partly cloudy or cloudy.

The cloud types show a predominance of stratiform and cirriform, with many days of cumuliform and stratocumuliform associated with the vortices. In view of the many days with cloudy skies that were experienced in November, it may be concluded that the severe restriction to flight operations due to the whiteout, which was actually experienced during November 1966, would have been inferred from this study.

3.4 December 1966

December showed an improvement in the number of clear days, with Byrd Camps Numbers One, Two and Three experiencing 3, 7 and 6 clear days, respectively (table 3.2). All camps showed a marked decrease in the number of cloudy days, with 15 cloudy days at Camp One, 12 cloudy days at Camp Two and only 9 cloudy days at Camp Three. As shown in table 3.2 and appendix D, periods of clear, partly cloudy and cloudy days were rather evenly spaced throughout the month.

As may be seen from figure 3.8, the mean vortex track moved southward to approximately 66° S., but fewer vortices transited Marie Byrd Land and Ellsworth Land, both in good agreement with climatology (fig. 3.5). The increased cloudiness over the ocean areas and decreased cloudiness over West Antarctica confirm the decreased cloudiness from spring to summer suggested by figure 3.2. Five secondary vortex tracks may be seen in figure 3.8 to rotate around the eastern portion of the Ross Sea and the western portion of Marie Byrd Land, as reflected in the greater cloudiness at Camp One.

In December, there were again many days with clear areas adjacent to cloudy areas covering one or more of the camps, indicating the possibility of greater helicopter operating time than is apparent from table 3.2. However, despite the improvement over November, whiteout conditions should still have been a deterrent to flight operations during a significant portion of the time, due to the areal extent of the sky cover during those days when cloudy skies existed over the respective camps.

Table 3.2. December 1966 Sky Cover for Selected Locations

	CAMP #1	CAMP #2	CAMP #3
	Clear 3, Ptly Cldy 13, Cldy 15	Clear 7, Ptly Cldy 12, Cldy 12	Clear 6, Ptly Cldy 16, Cldy 9
1	Cldy	Cldy	Ptly Cldy
2	Ptly Cldy	Cldy	Ptly Cldy
3	Ptly Cldy	Ptly Cldy	Ptly Cldy
4	Cldy	Cldy	Ptly Cldy
5	Cldy	Cldy	Clear
6	Cldy	Cldy	Clear
7	Clear	Clear	Ptly Cldy
8	Ptly Cldy	Clear	Clear
9	Cldy	Ptly Cldy	Ptly Cldy
10	Cldy	Cldy	Cldy
11	Ptly Cldy	Clear	Ptly Cldy
12	Cldy	Ptly Cldy	Ptly Cldy
13	Cldy	Cldy	Clear
14	Clear	Clear	Clear
15	Clear	Clear	Ptly Cldy
16	Ptly Cldy	Ptly Cldy	Cldy
17	Cldy	Ptly Cldy	Cldy
18	Ptly Cldy	Cldy	Cldy
19	Cldy	Ptly Cldy	Cldy
20	Ptly Cldy	Cldy	Cldy
21	Cldy	Cldy	Cldy
22	Ptly Cldy	Cldy	Ptly Cldy
23	Cldy	Cldy	Ptly Cldy
24	Ptly Cldy	Ptly Cldy	Ptly Cldy
25	Ptly Cldy	Ptly Cldy	Cldy
26	Ptly Cldy	Ptly Cldy	Cldy
27	Cldy	Ptly Cldy	Ptly Cldy
28	Cldy	Ptly Cldy	Ptly Cldy
29	Cldy	Ptly Cldy	Clear
30	Ptly Cldy	Clear	Ptly Cldy
31	Ptly Cldy	Clear	Ptly Cldy

3.5 January 1967

January experienced the least number of cloudy days, with 13 at Byrd Camp Number One, 6 at Camp Two and 10 at Camp Three; but the number of clear days decreased to 2 to 3 (table 3.3). This change from December should not be entirely unexpected; for as indicated in climatology and as borne out by figure 3.9 and appendix E, the decreased intensity and number of large storms are compensated by continued southward displacement of the mean storm track. Further, the increased air temperature suggests the probability of greater amounts of water vapor; and the recession of the ice edge permits oceanic cloudiness to affect the coastal areas more readily. Hence, even though the reduction in cyclonic activity should result in a decrease in cloudy days, other factors should cause a decrease in the number of completely clear days; and the average cloudiness of slightly more than 50% indicated by figure 3.2 seems in general agreement with this study.

Whiteout should hinder flight operations in January also; for, although the number of cloudy days has decreased, the thickness and amount of the clouds observed in the partly cloudy areas can produce whiteout to some extent.

Table 3.3. January 1967 Sky Cover for Selected Locations

	Clear 3	Ptly Cldy 15	Cldy 13	Clear 3	Ptly Cldy 22	Cldy 6	Clear 2	Ptly Cldy 19	Cldy 10
	CAMP #1			CAMP #2			CAMP #3		
1	Ptly Cldy			Clear			Ptly Cldy		
2	Ptly Cldy			Clear			Ptly Cldy		
3	Ptly Cldy			Ptly Cldy			Ptly Cldy		
4	Cldy			Clear			Clear		
5	Cldy			Ptly Cldy			Ptly Cldy		
6	Cldy			Ptly Cldy			Ptly Cldy		
7	Cldy			Ptly Cldy			Ptly Cldy		
8	Cldy			Ptly Cldy			Cldy		
9	Cldy			Ptly Cldy			Ptly Cldy		
10	Cldy			Cldy			Ptly Cldy		
11	Cldy			Ptly Cldy			Ptly Cldy		
12	Ptly Cldy			Ptly Cldy			Ptly Cldy		
13	Clear			Ptly Cldy			Ptly Cldy		
14	Clear			Ptly Cldy			Cldy		
15	Ptly Cldy			Ptly Cldy			Cldy		
16	Ptly Cldy			Ptly Cldy			Cldy		
17	Ptly Cldy			Cldy			Ptly Cldy		
18	Clear			Cldy			Cldy		
19	Cldy			Ptly Cldy			Cldy		
20	Ptly Cldy			Ptly Cldy			Ptly Cldy		
21	Ptly Cldy			Cldy			Cldy		
22	Ptly Cldy			Ptly Cldy			Cldy		
23	Cldy			Ptly Cldy			Ptly Cldy		
24	Ptly Cldy			Ptly Cldy			Clear		
25	Ptly Cldy			Ptly Cldy			Ptly Cldy		
26	Cldy			Ptly Cldy			Cldy		
27	Cldy			Cldy			Cldy		
28	Ptly Cldy			Ptly Cldy			Ptly Cldy		
29	Cldy			Ptly Cldy			Ptly Cldy		
30	Ptly Cldy			Cldy			Ptly Cldy		
31	Ptly Cldy			Cldy			Ptly Cldy		

4. CONCLUSIONS

Table 4.1 summarizes the monthly variations in cloudiness at Byrd Camps Numbers One, Two and Three. November 1966 was substantially more cloudy than December 1966 and January 1967, with little appreciable difference among the three camps. During December 1966 and January 1967, Camp One was cloudier than Camps Two and Three.

Vortex tracks prepared from the satellite photographs and their derived neph-analyses agree basically with climatological storm tracks, except that the number of vortices transiting coastal West Antarctica in November 1966 appears greater than normal. Vortex tracks prepared for all months agree well with the generally accepted view [1, 6] that the storm track roughly parallel to the coast is more common than that between the Ross and Weddell Seas.

There is every reason to believe from the limited data available, that November will be a cloudier month than December and January; and that owing to the greater probability of common large-storm tracks, all three camps will be cloudy at the same time during this month. The decrease in cloud cover from November to December and January in 1966-67 was noteworthy; but was probably a slightly greater than normal improvement, for the reason that November 1966 was apparently cloudier than the average due to the unusual cyclonic activity. Whiteout will certainly be a serious handicap to flight operations in all months; but there is a reasonable probability of acceptable operating conditions 30 to 35% of the time at Camp One, and 40 to 45% of the time at Camps Two and Three during December and January.

Table 4.1. SKY COVER

		Nov. Days	Nov. %	Dec. Days	Dec. %	Jan. Days	Jan. %
CAMP #1	CLEAR	1	3	3	10	3	10
	PARTLY CLOUDY	5	17	13	42	15	48
	CLOUDY	24	80	15	48	13	42
CAMP #2	CLEAR	2	7	7	22	3	10
	PARTLY CLOUDY	6	20	12	39	22	71
	CLOUDY	22	73	12	39	6	19
CAMP #3	CLEAR	1	3	6	19	2	7
	PARTLY CLOUDY	6	20	16	52	19	61
	CLOUDY	23	77	9	29	10	32

Description	Amount
CLEAR =	≤ 0.3
PARTLY CLOUDY =	0.31-0.79
CLOUDY =	≥ 0.8

Three Month Average

	CAMP #1	CAMP #2	CAMP #3
CLEAR	8 %	13 %	10 %
PARTLY CLOUDY	35 %	43 %	44 %
CLOUDY	57 %	44 %	46 %

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APPENDIX A

WHITEOUT

"Whiteout" is an atmospheric optical phenomenon characteristic of snow-covered polar regions under overcast skies and lighting conditions such that the greyish-white snow blends with the grey clouds into a uniform background which lacks shadows, detail and perspective. In such conditions the observer, whether in the air or on the ground, appears to be engulfed in a uniformly white glow in which neither the horizon nor clouds are discernible. All sense of depth and orientation is lost; only very dark nearby objects can be seen.

"Whiteout" occurs over an unbroken snow cover and beneath a uniformly overcast sky, usually cirrostratus, altostratus, stratus or stratocumulus, under circumstances in which the light from the sky is approximately equal to that from the snow surface. Several publications attribute "whiteout" also to blowing snow, when hydrometeors suspended in the air constitute an obstruction to vision. However, in a true "whiteout", forward visibility is apparently reduced even though the atmosphere is actually transparent and hydrometeors are not present. It is the inability to distinguish snow-covered objects in the path of an aircraft or ground traveller which makes the phenomenon so dangerous.

"Whiteout" occurs most frequently in spring and fall when the sun is near the horizon (below 20° altitude), particularly when light intensification results from lack of absorption between snow and cloud cover with the added effect of reflected light.

APPENDIX B

NEPHANALYSIS LEGEND

1. BOUNDRIES

- Major Cloud System
- Limit of Ice Edge
- Definite
- Indefinite

2. CLOUD AMOUNT (COVERAGE)

O	Open ≤ 0.20
MOP	Mostly Open 0.21 - 0.50
MCO	Mostly Covered 0.51 - 0.79
C	Covered ≥ 0.80

3. CLOUD TYPES

- Cumuliform
- Cb
- Strato-Cumuliform
- Cirriform
- Stratiform

4. OTHER

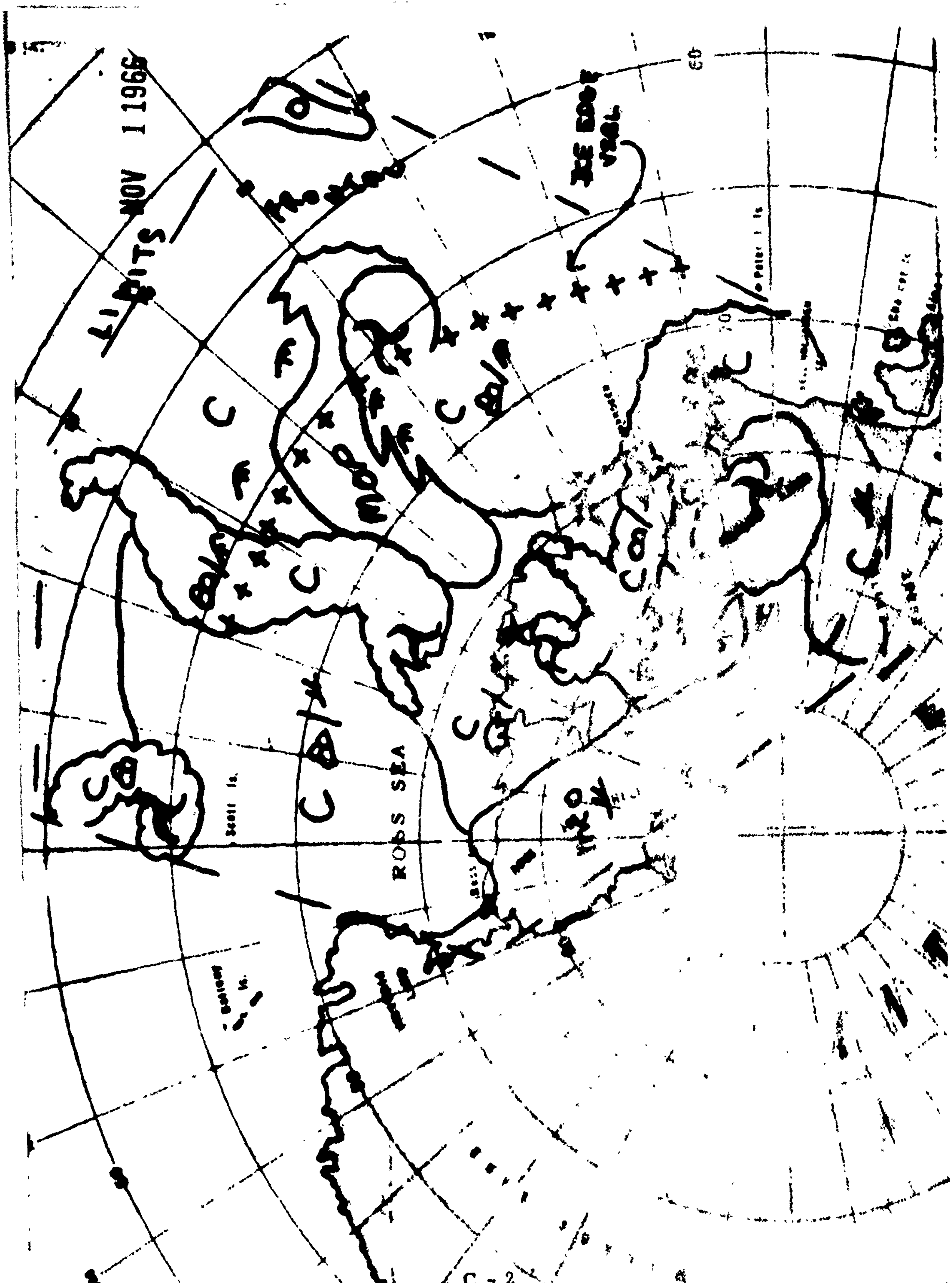
	Proposed Camp Location
MTNS	Mountains
ICE FLOES	Sea or Shelf Ice Visible in Western Ross Sea

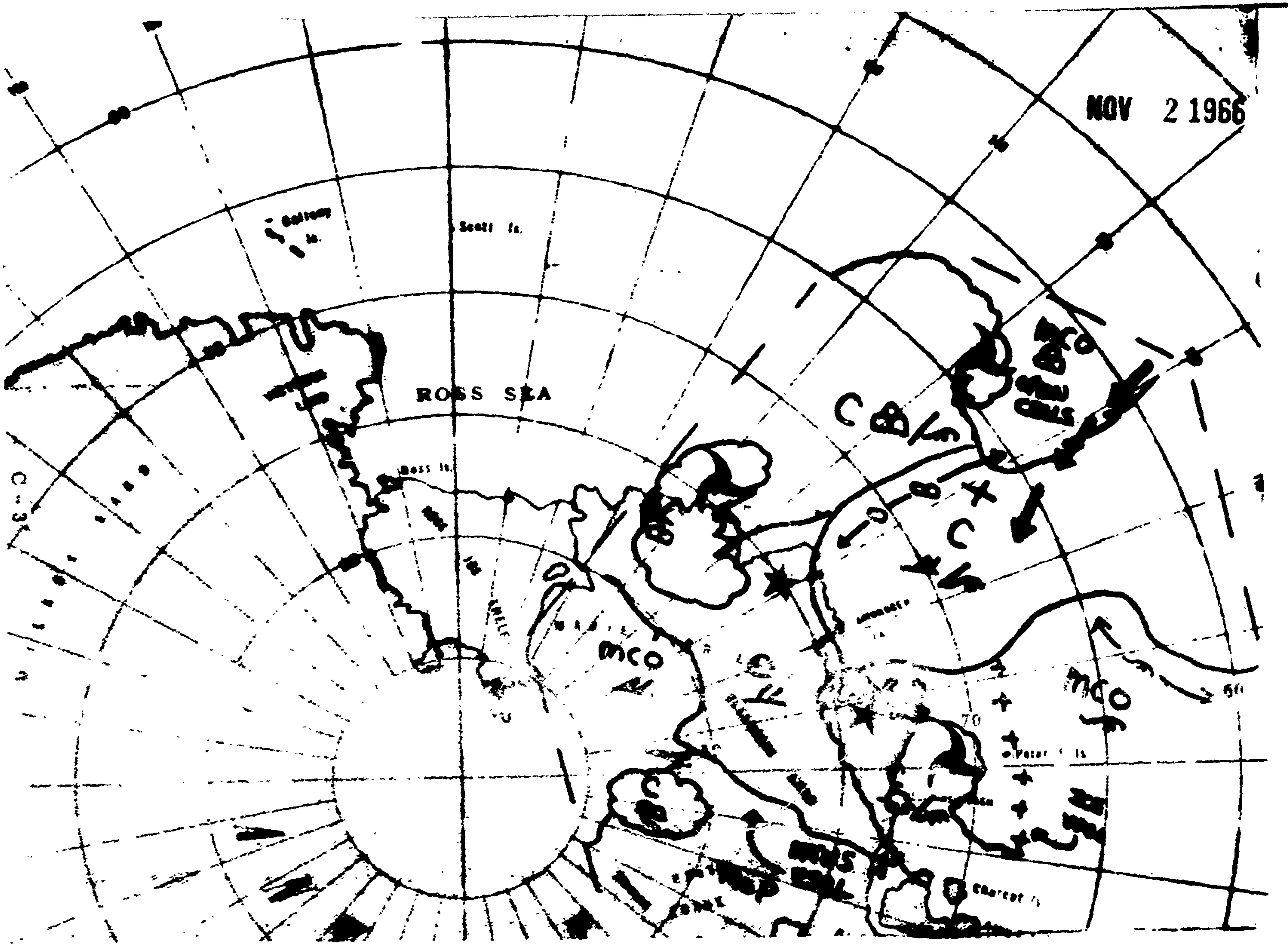
5. SYMBOLS

- Vortex
- Vorticity Center
- PVA Max
- Transverse Bands or Waves
- Jet Stream
- Bright (highly reflective cloud mass)
- Cloud Lines (may be , , ,)
- Cloud Line, Tenuous
- Building Cloud Lines
- Striations
- Eddies

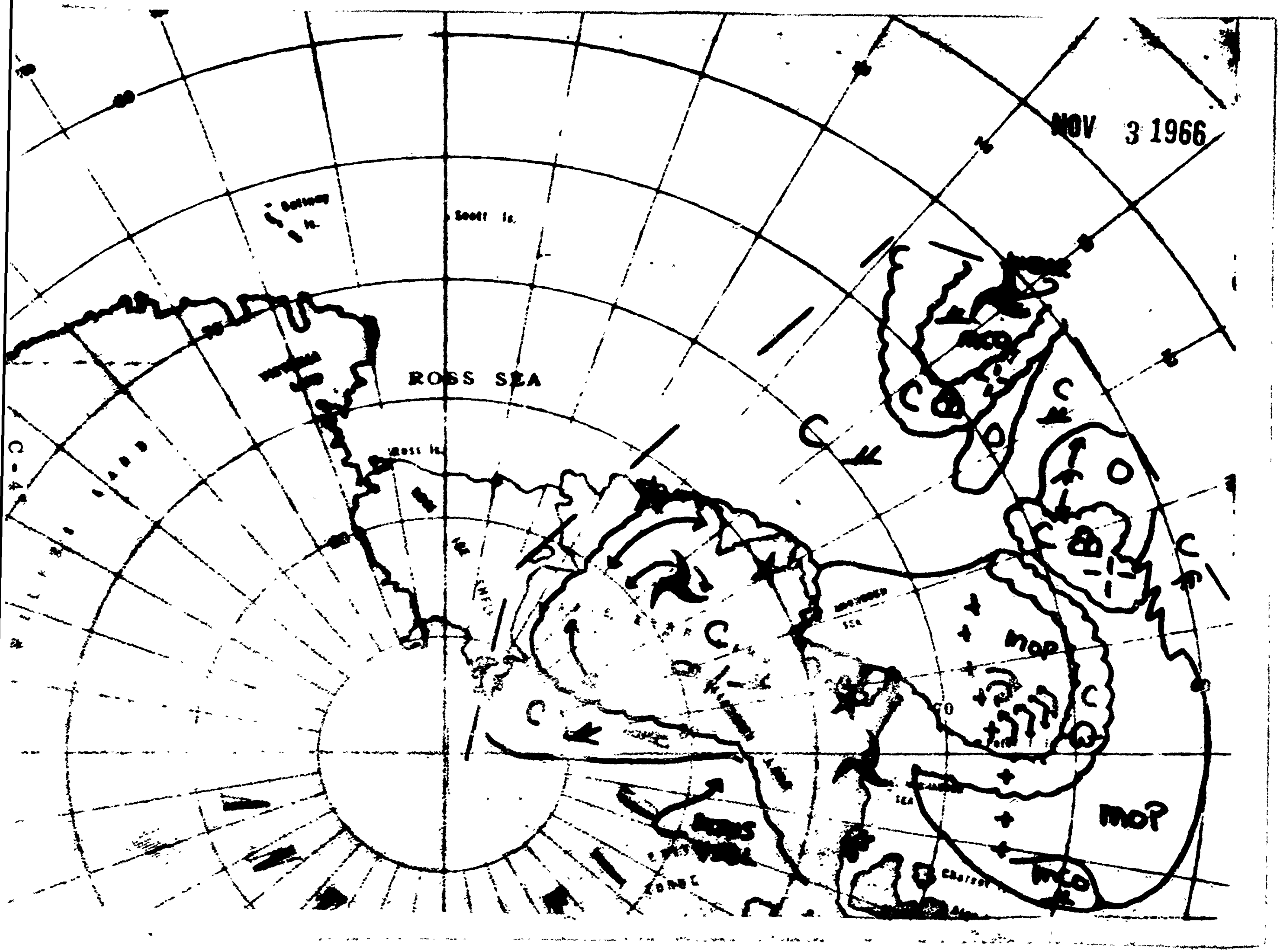
APPENDIX C

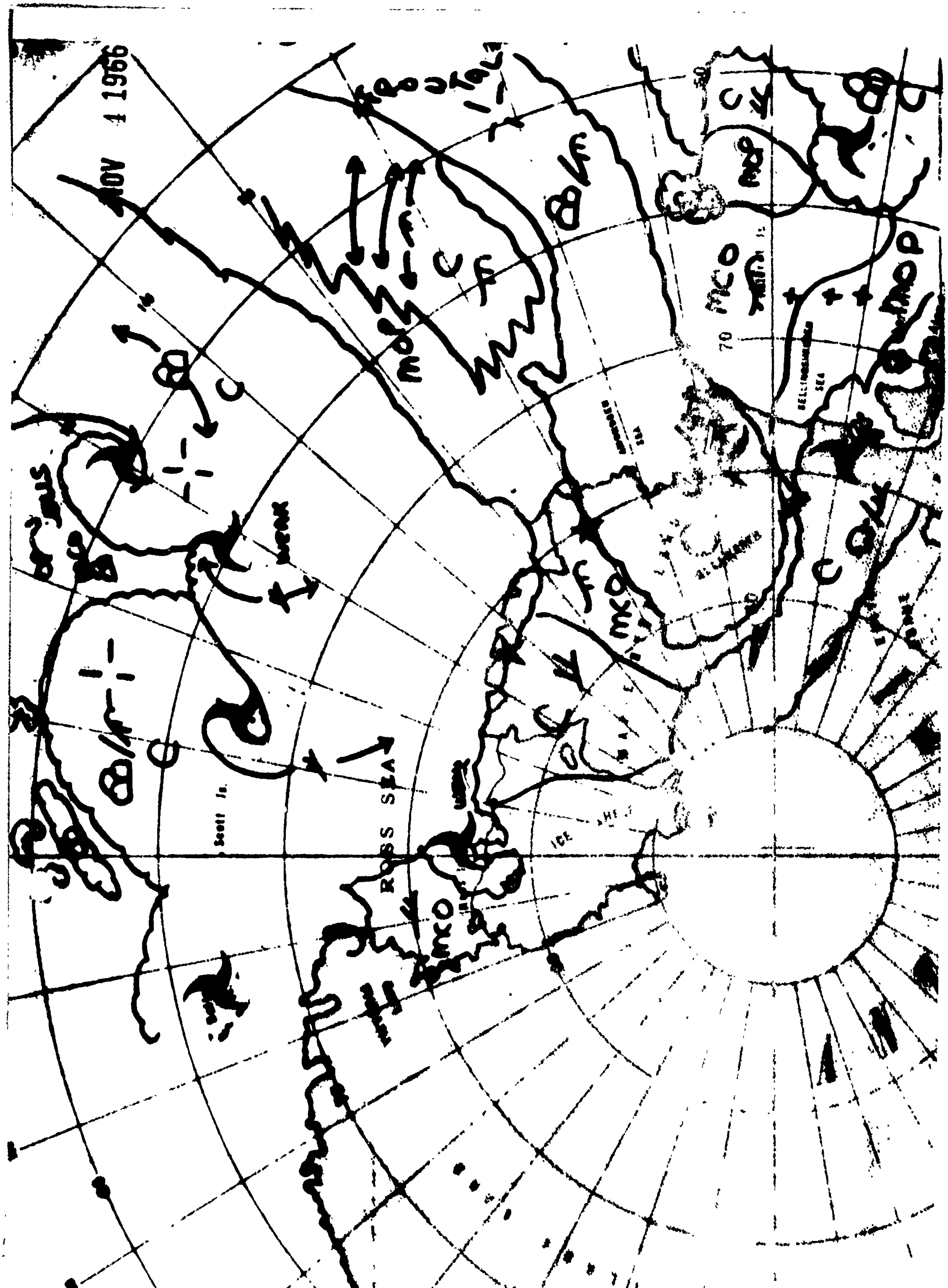
NOVEMBER 1966 NEPHANALYSES


LIMITS NOV 1 1966
ICE EDGE
ROSS SEA
Scott Is.
Peter I Is.
60
70



NOV 2 1966
ROSS SEA
Scott Is.
Balleny Is.
Ross Is.
CB/m
OPEN CELLS
MCO
C
MCO
Peter I Is.
Charcot Is.


NOV 3 1966
ROSS SEA
Scott Is.
Balleny Is.
Ross Is.
mop
mo?
mco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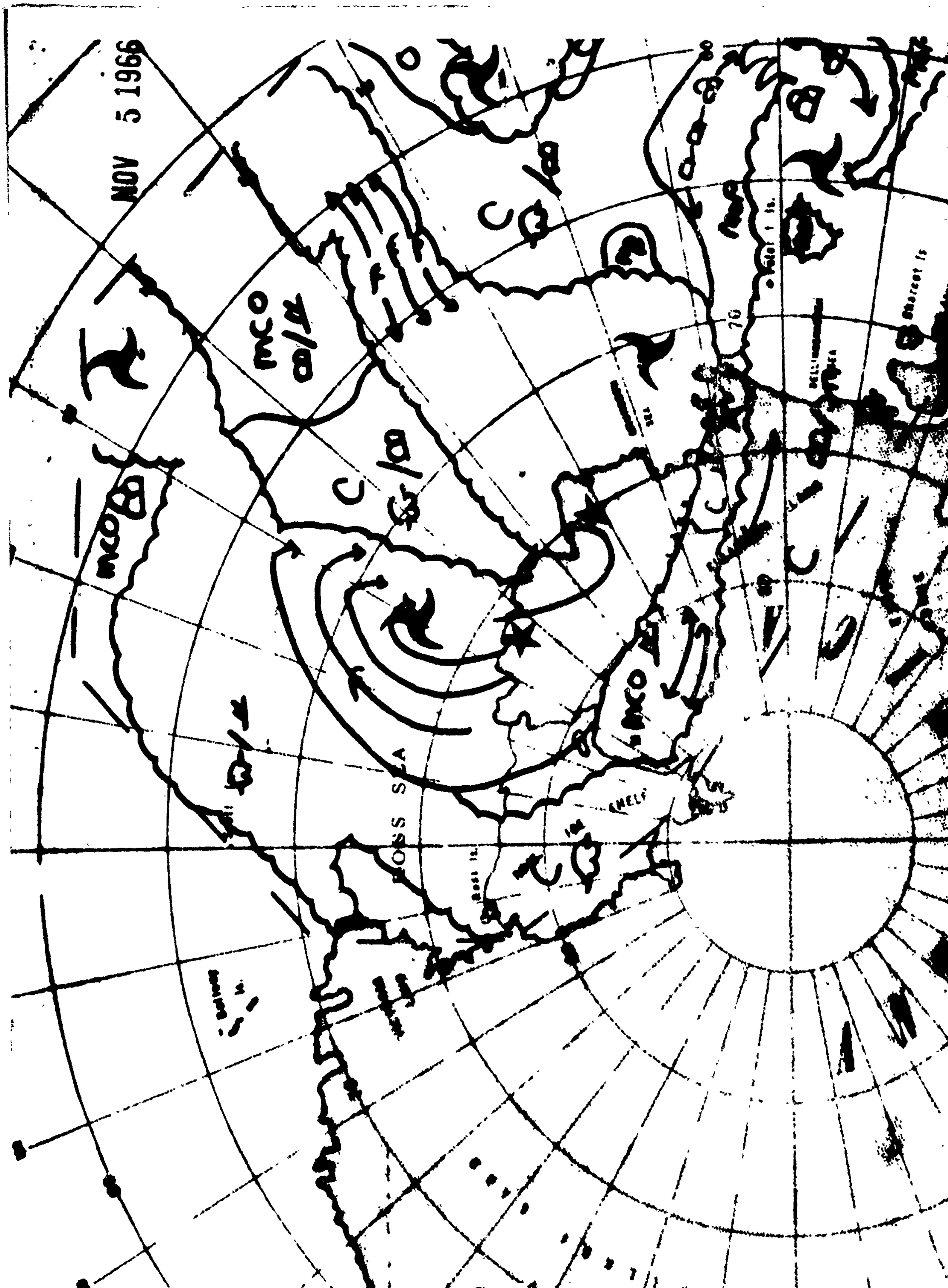
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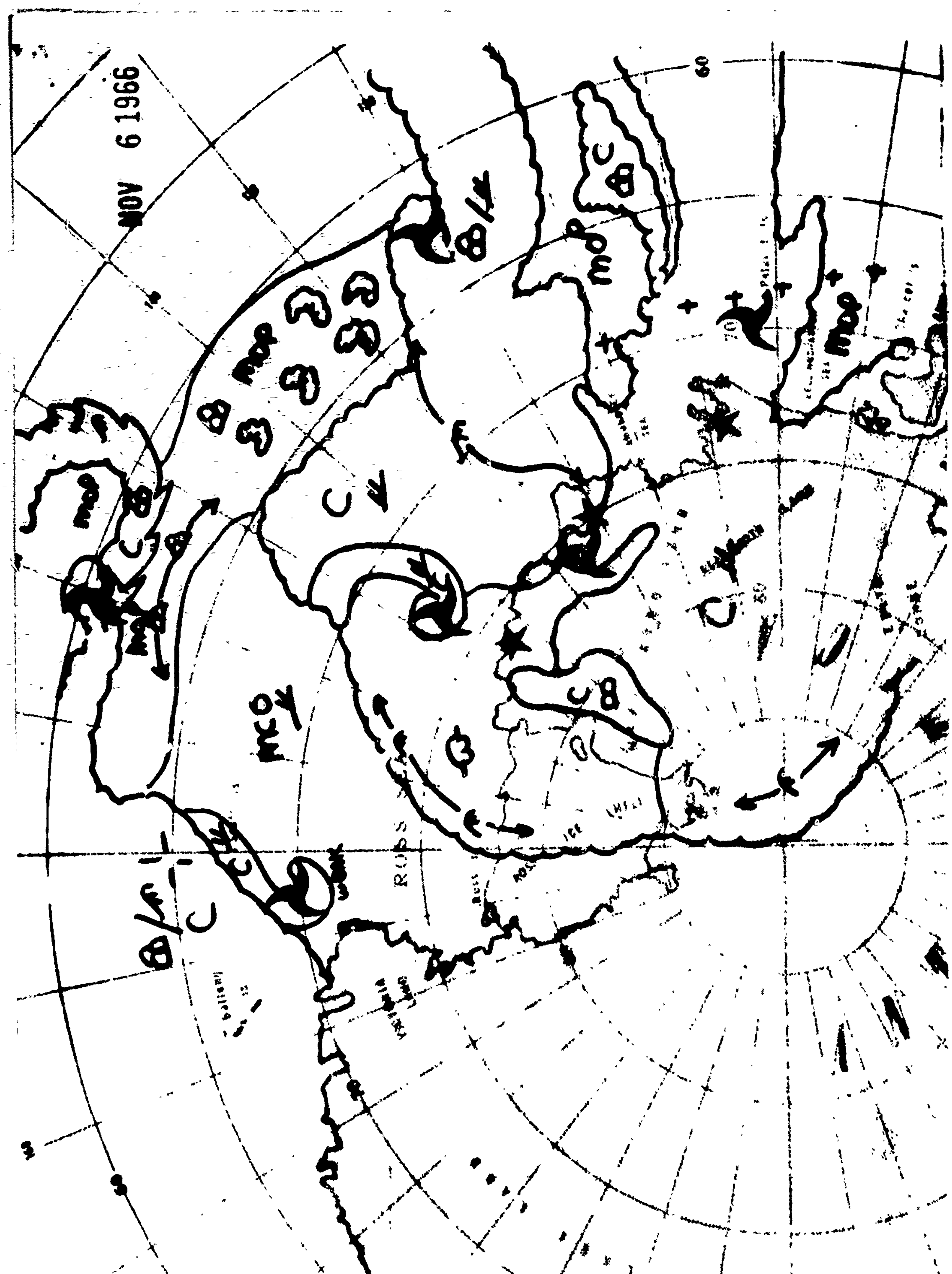
MCO
ROSS SEA
Ross Is.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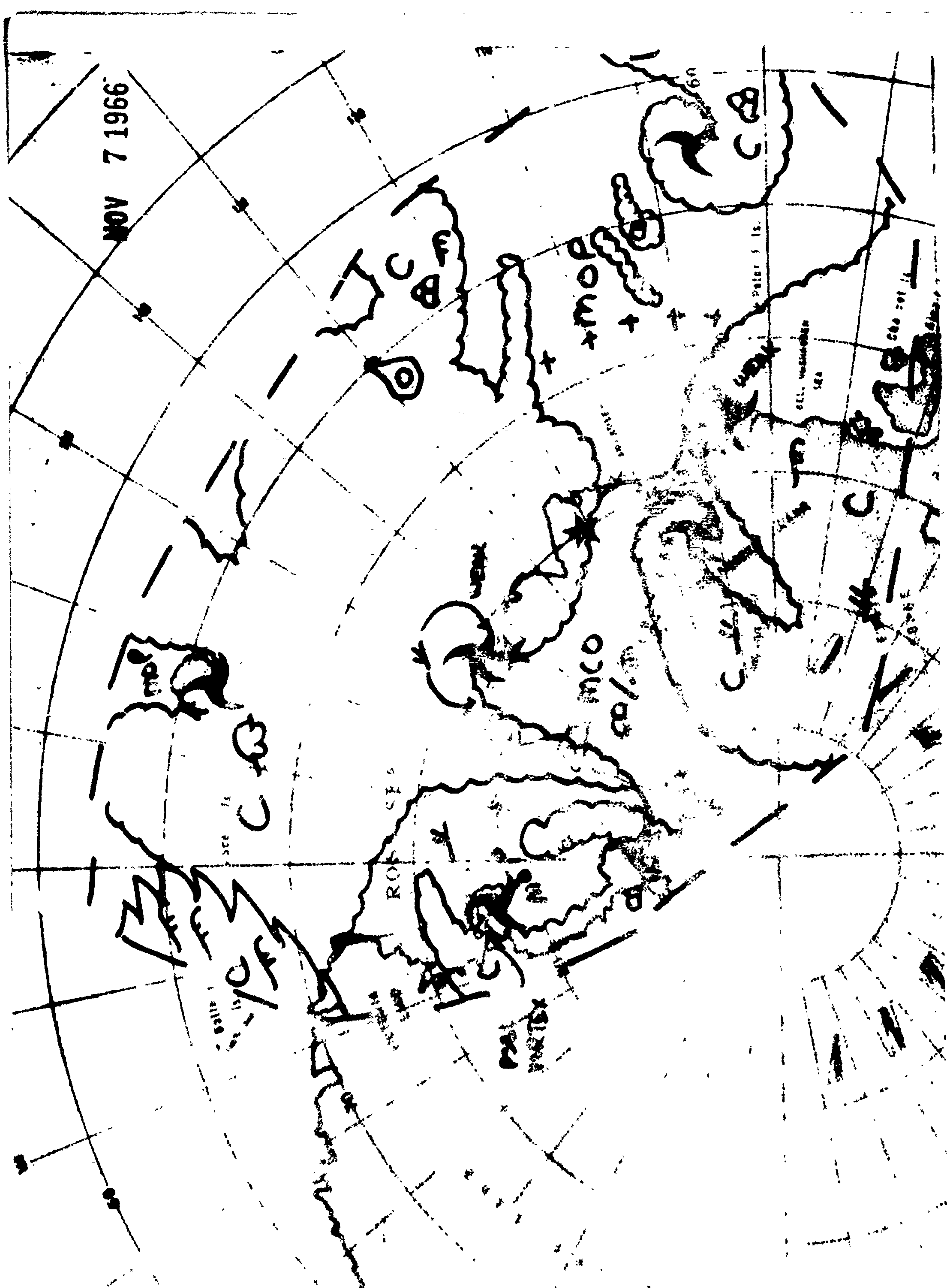
ROSS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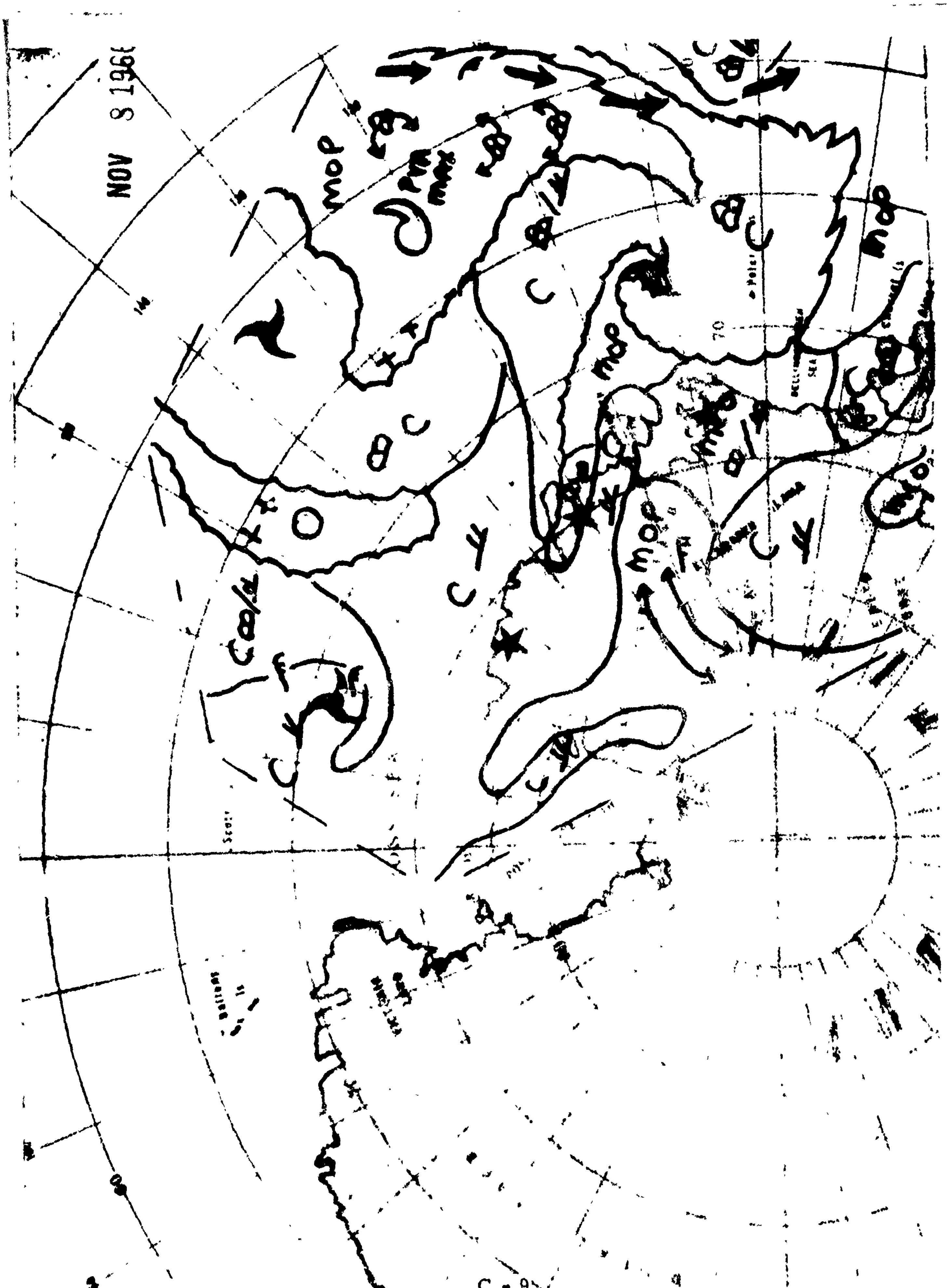
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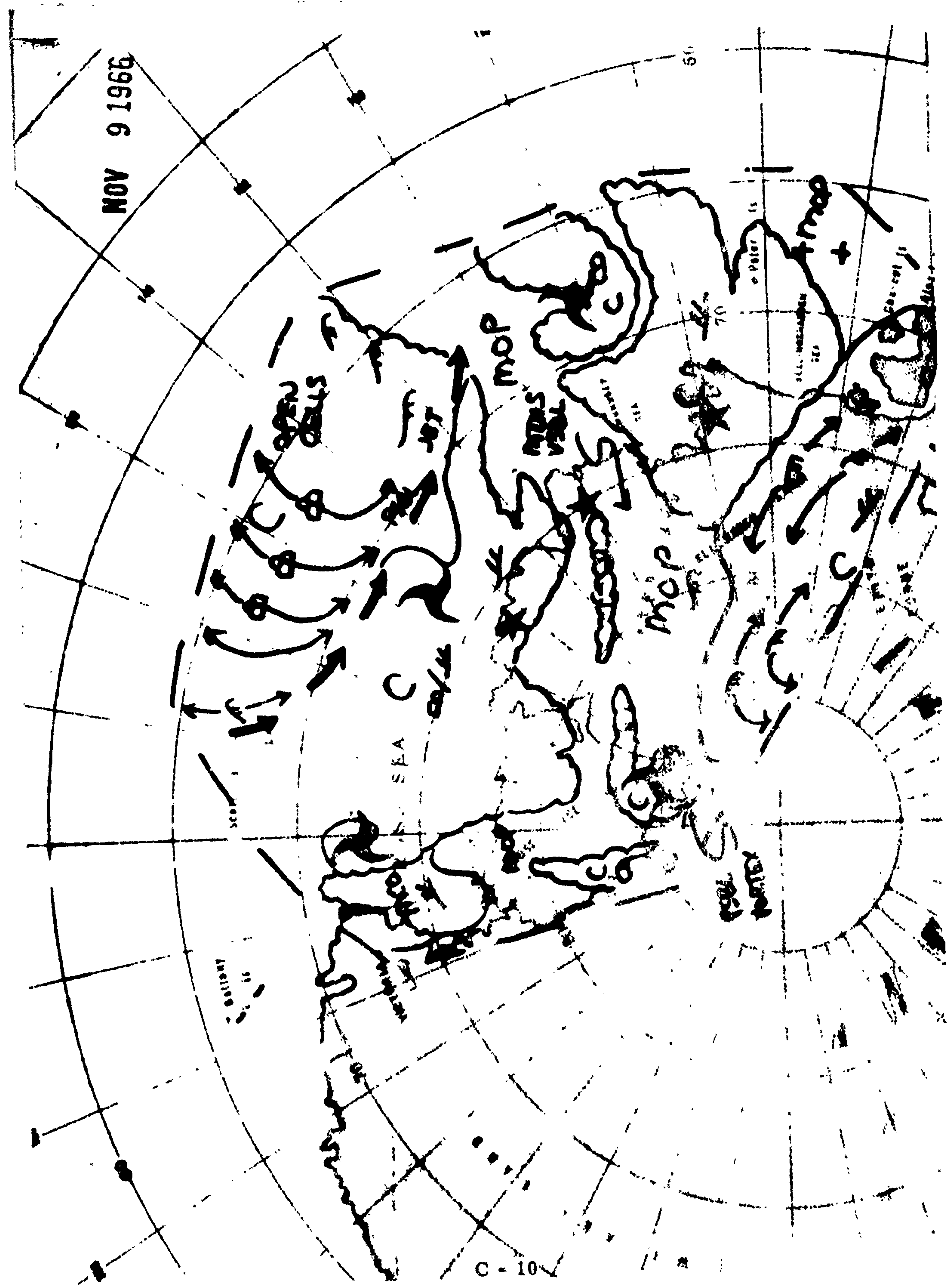
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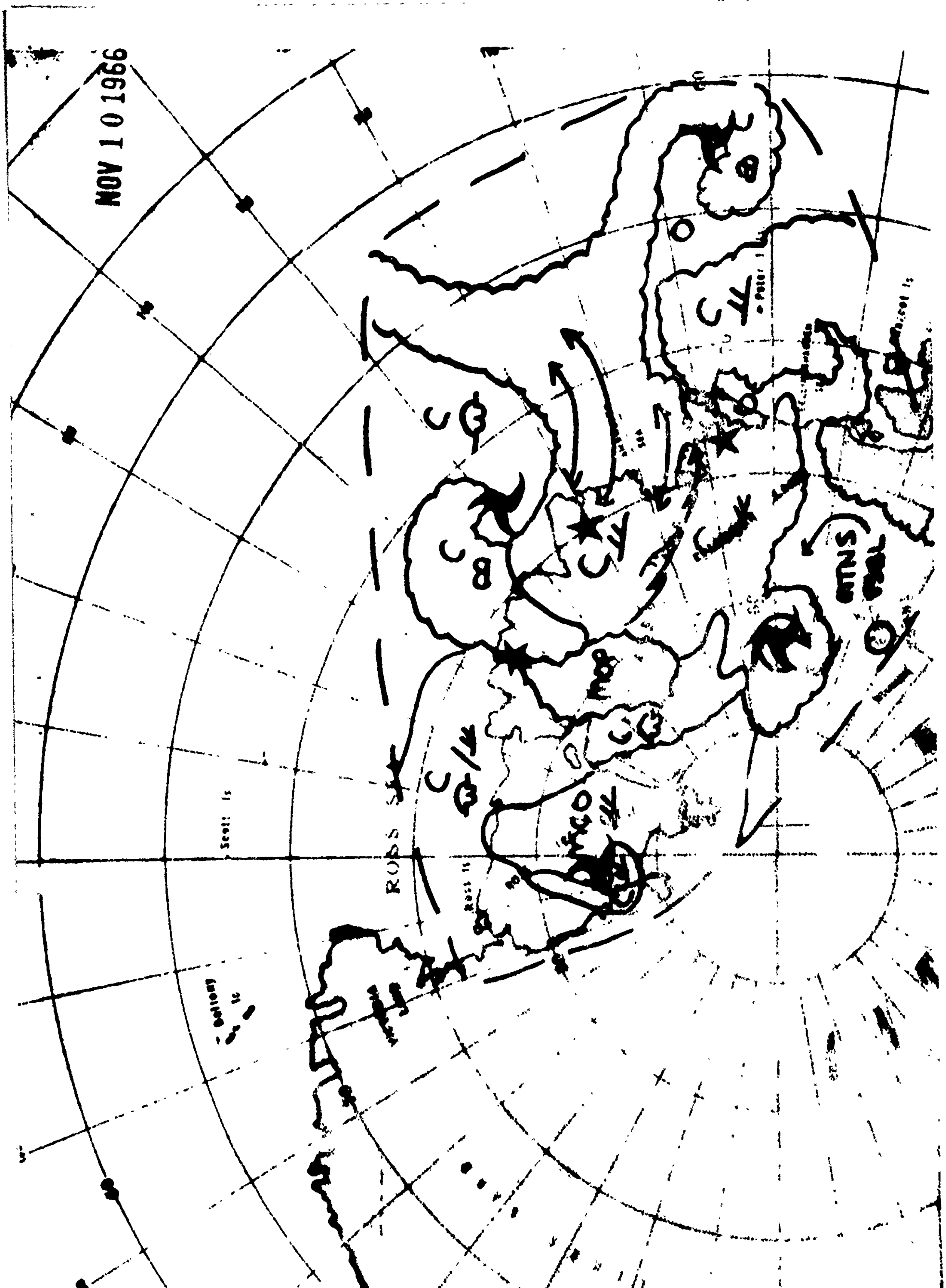
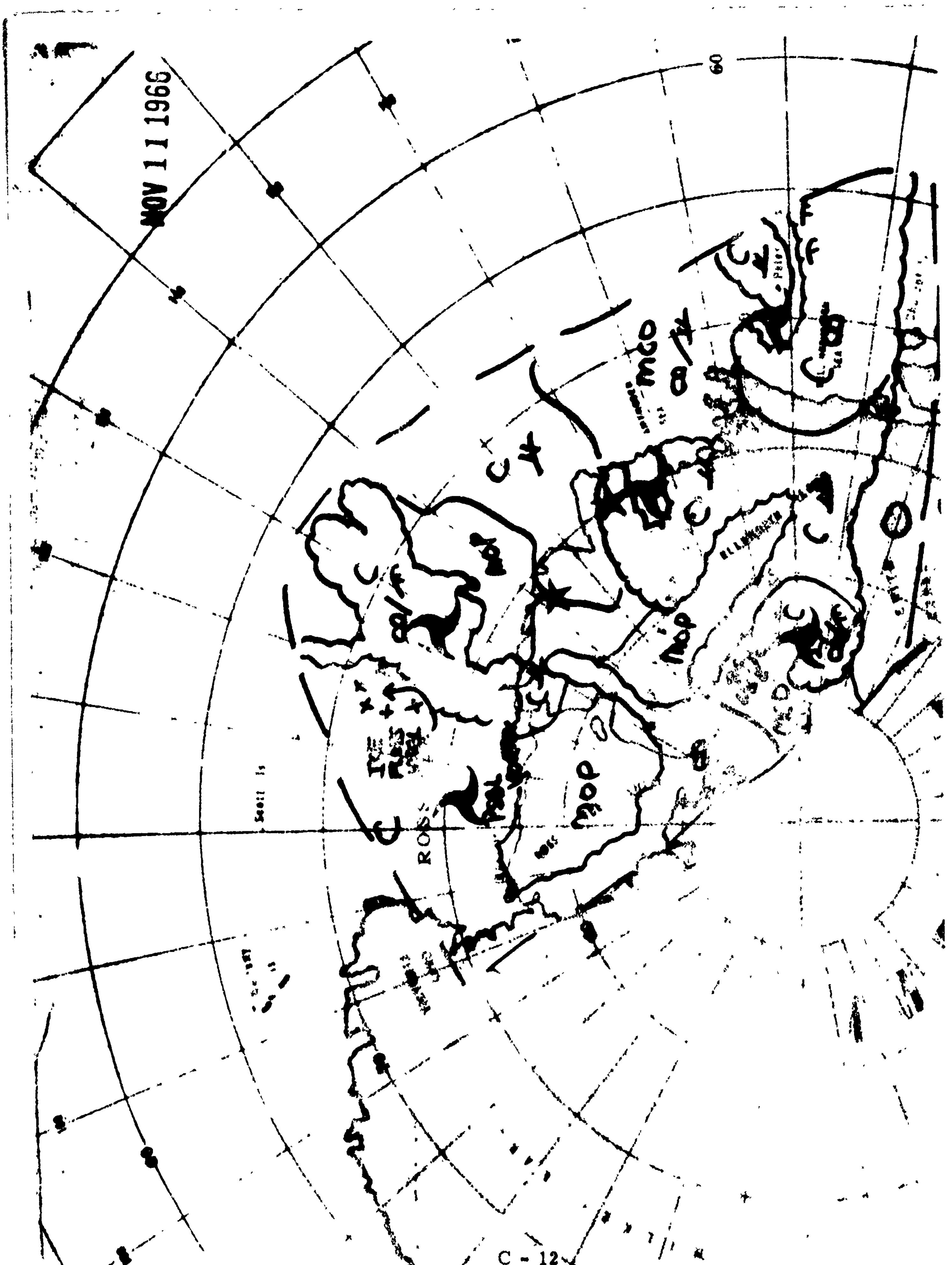
OPEN CELLS
MOP
JET
C
SEA


NOV 1 0 1966
ROSS S
Scott Is



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60
ROSS
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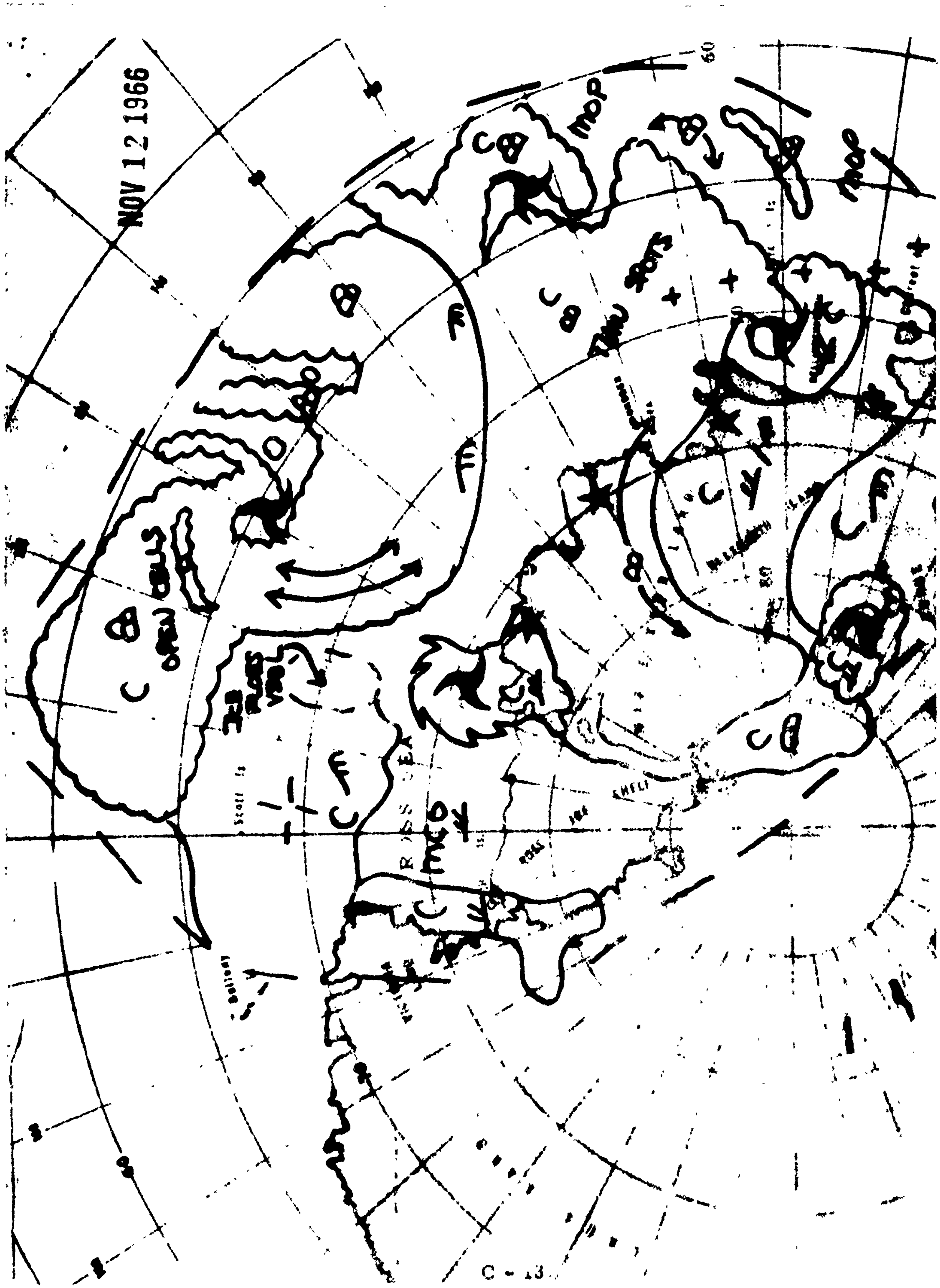

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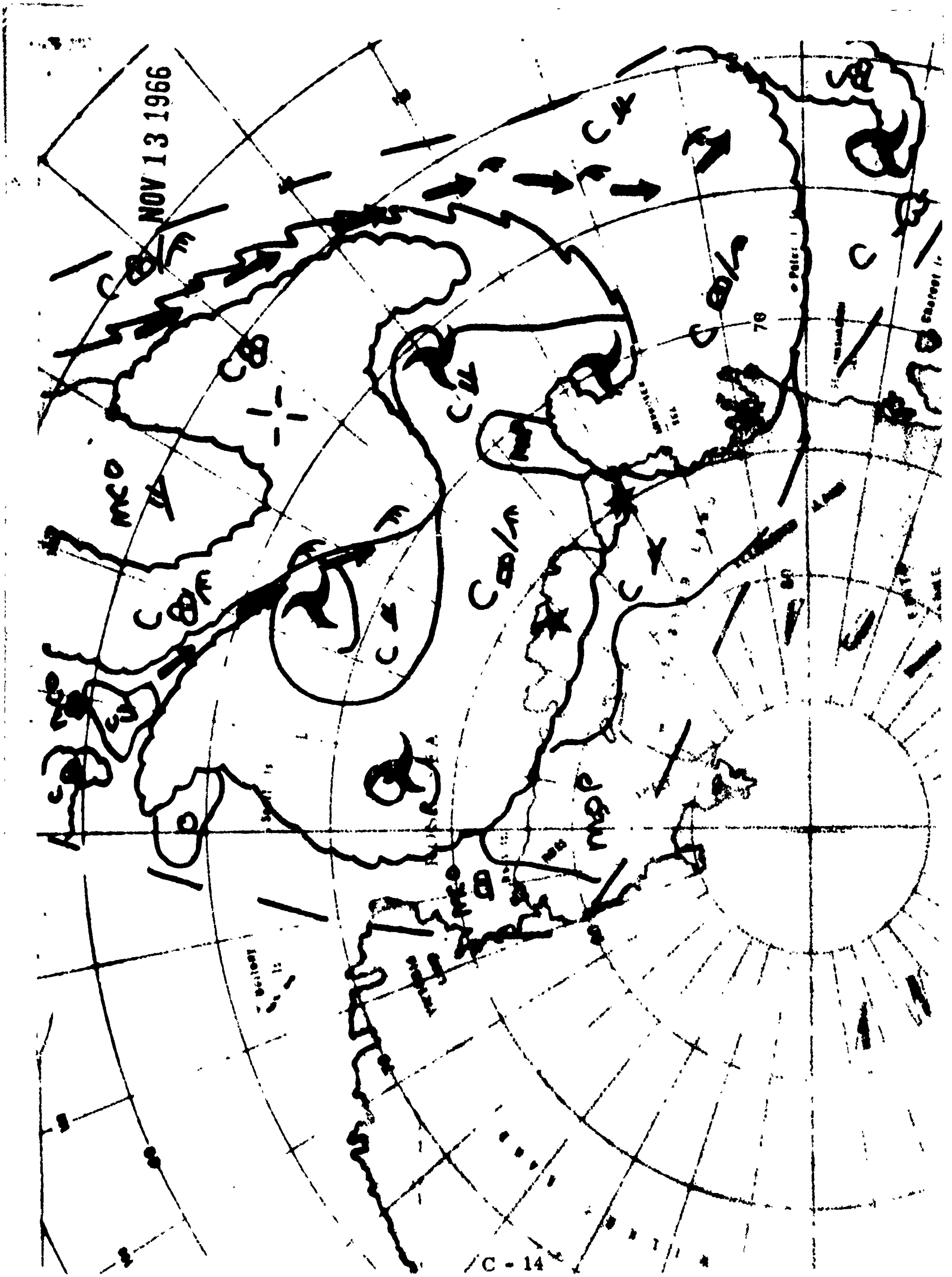
OPEN CELLS
THIN SPOTS
MCD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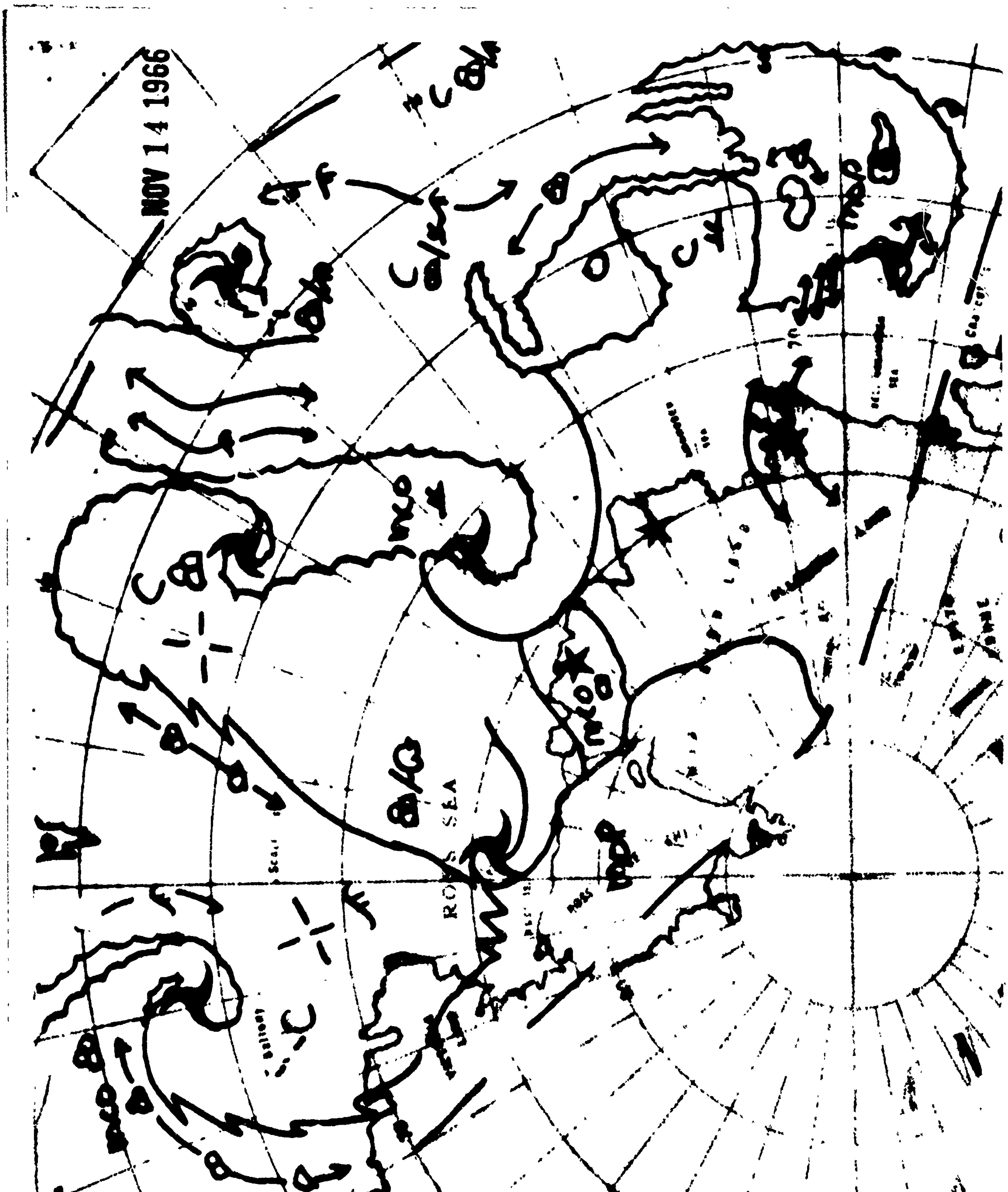
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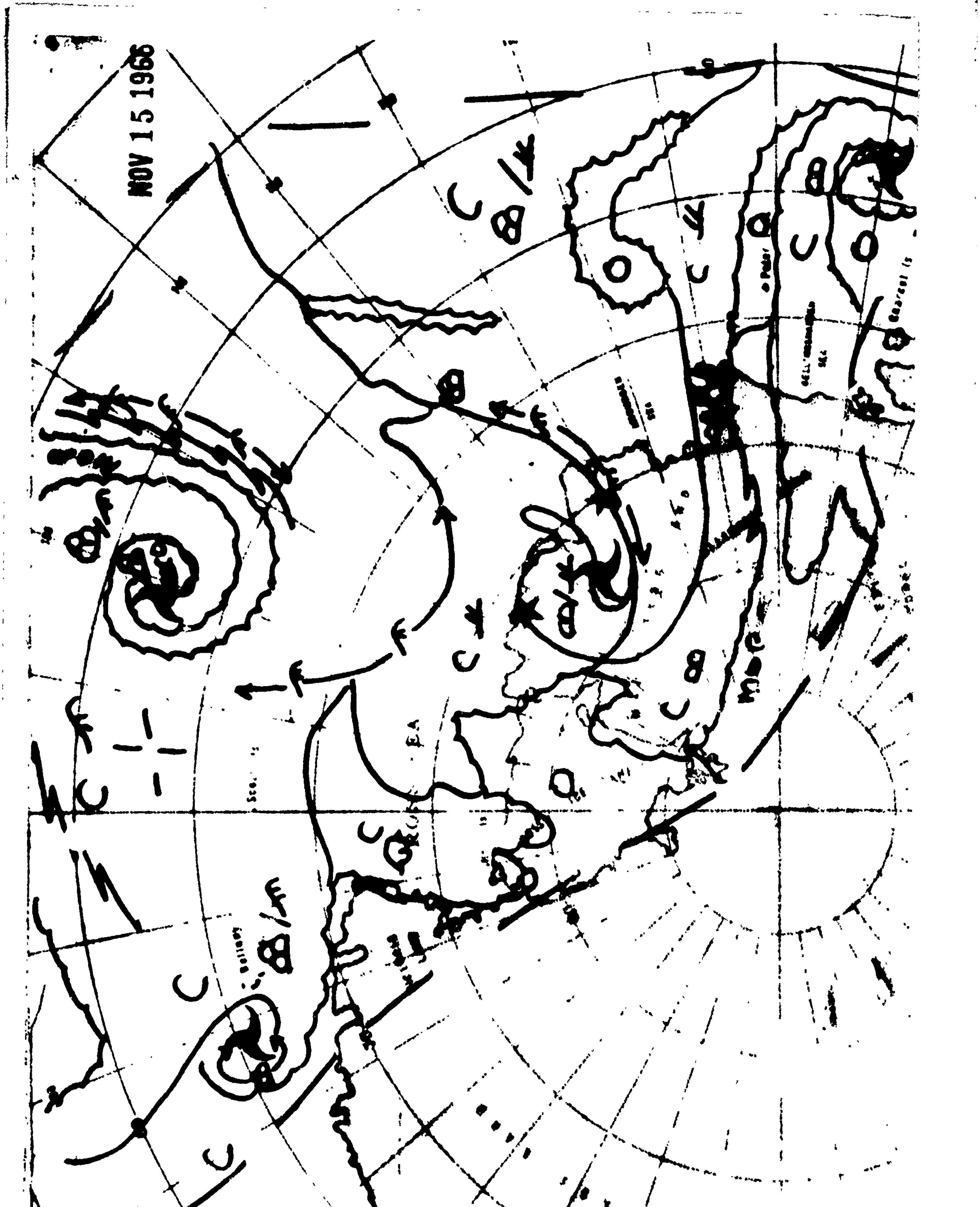
ROSS SEA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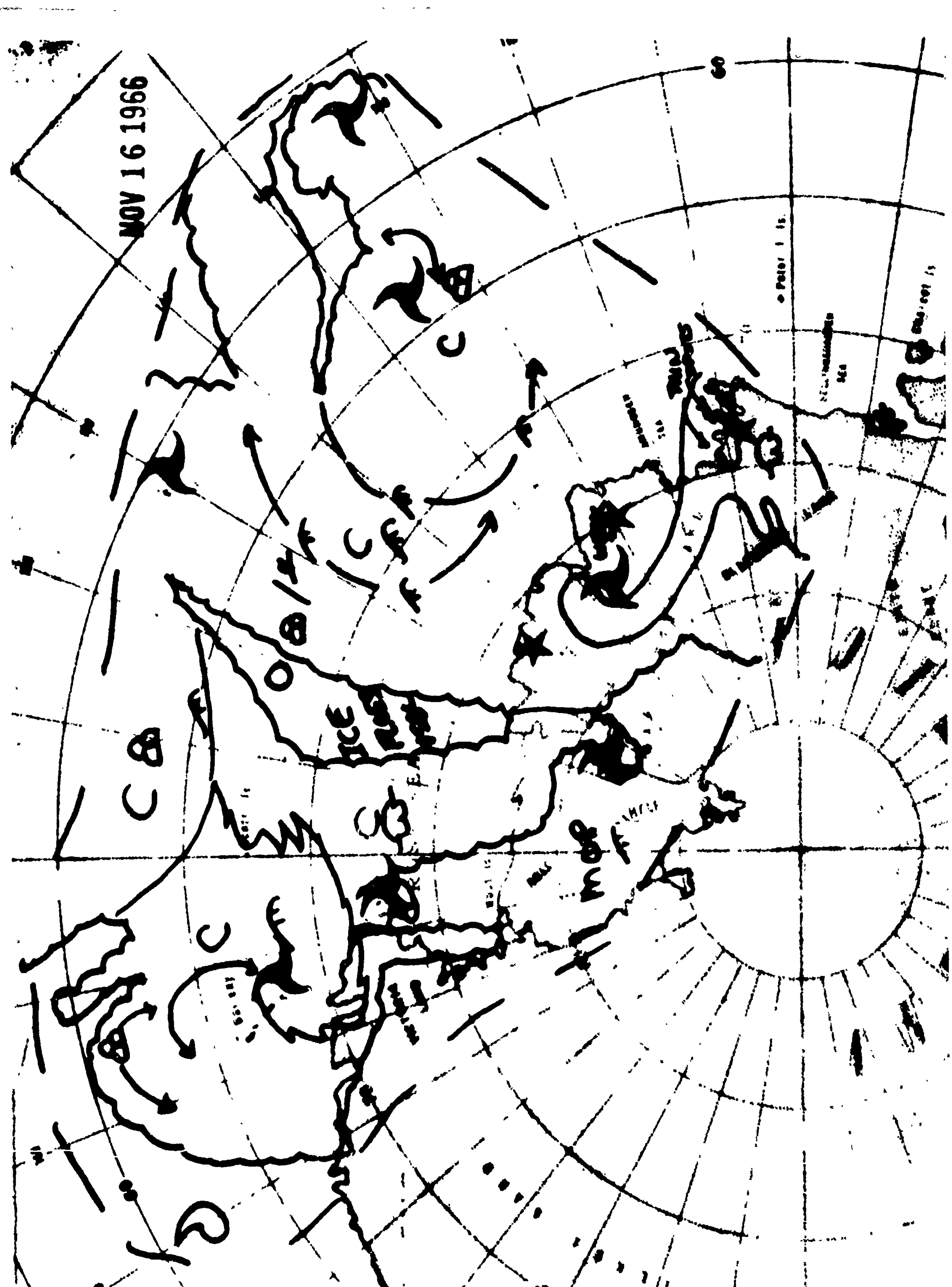
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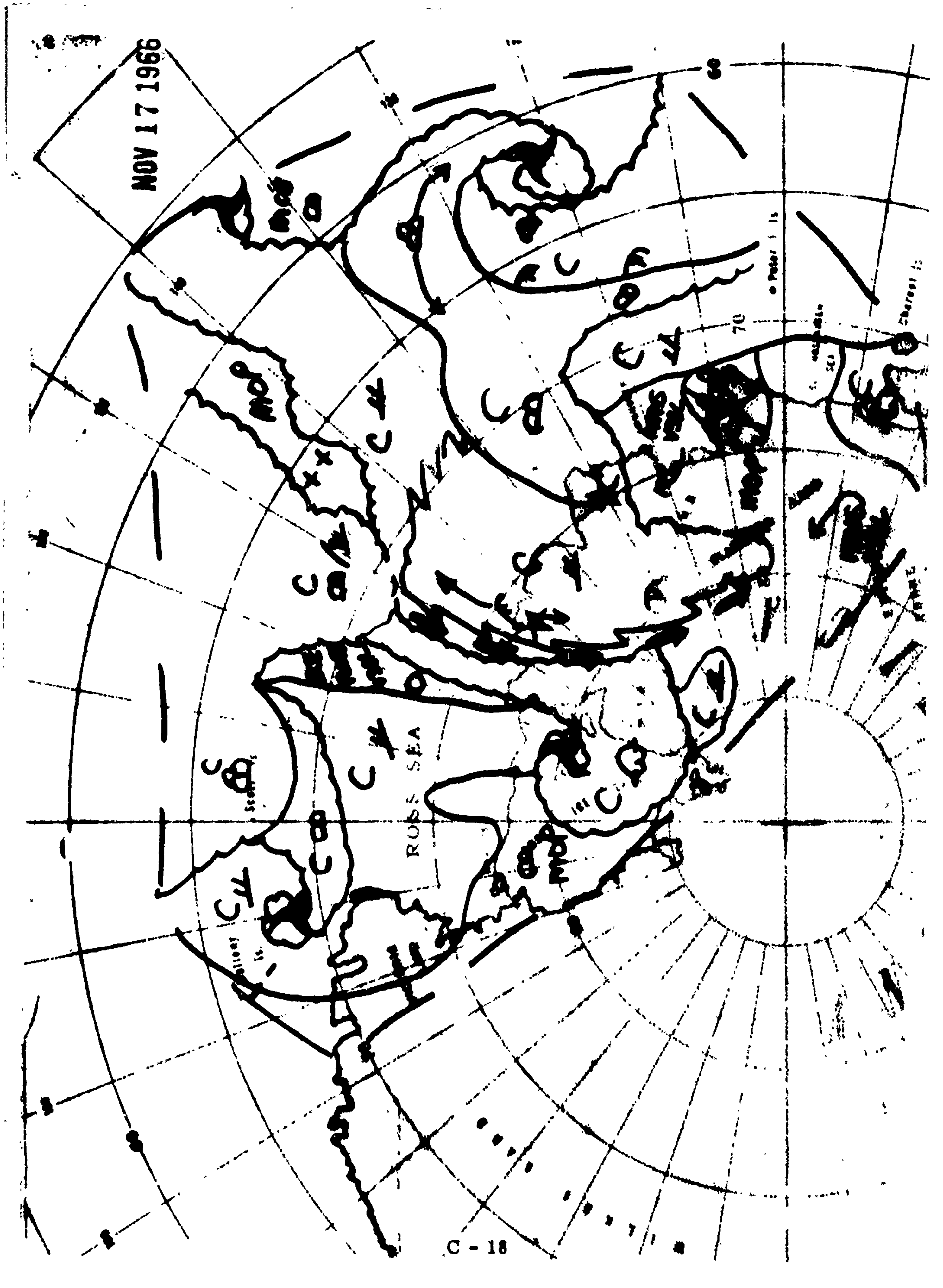
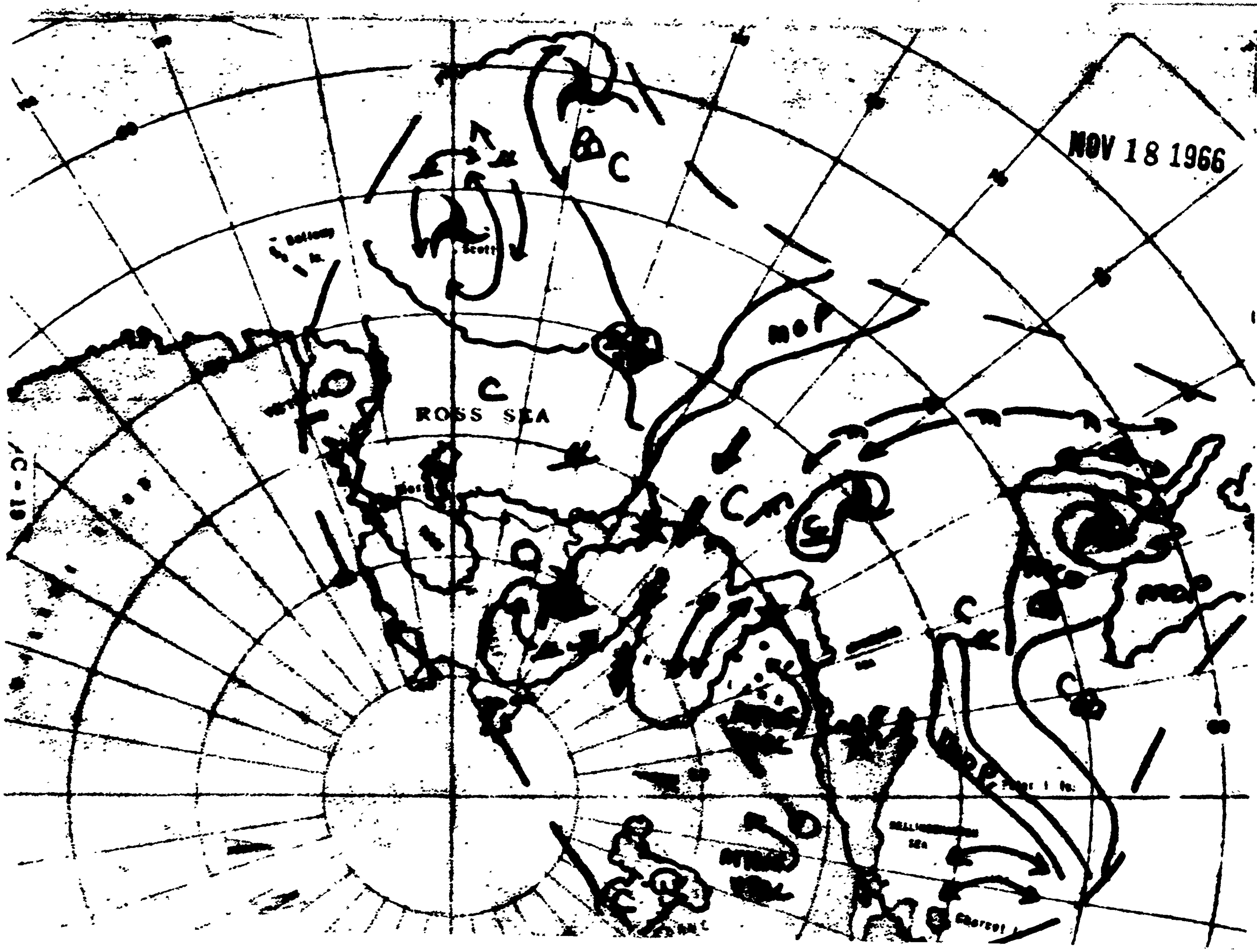
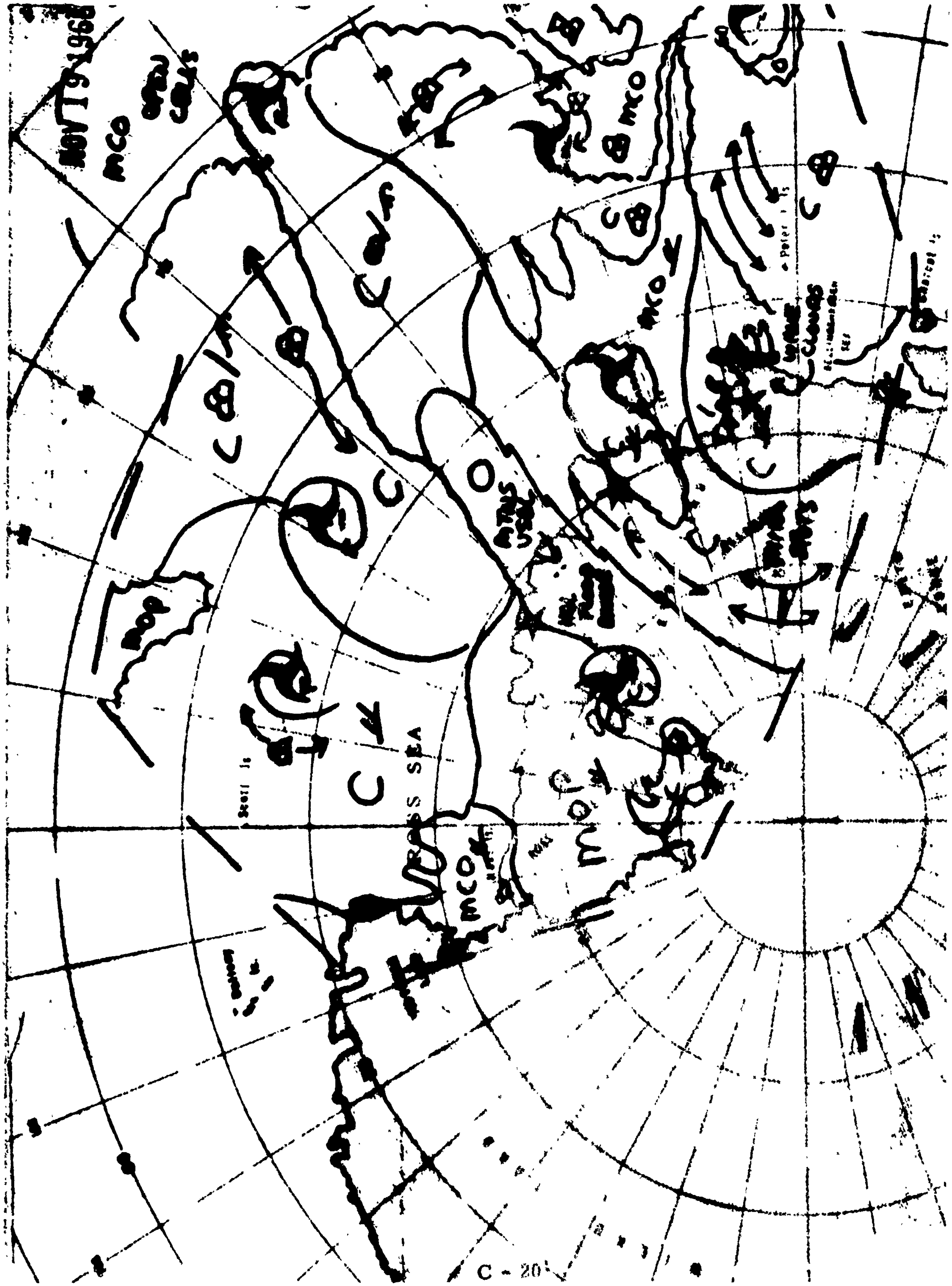

NOV 17 1966
ROSS SEA
Peter I Is
Charcot Is
Scott
Balleny Is



NOV 18 1966
ROSS SEA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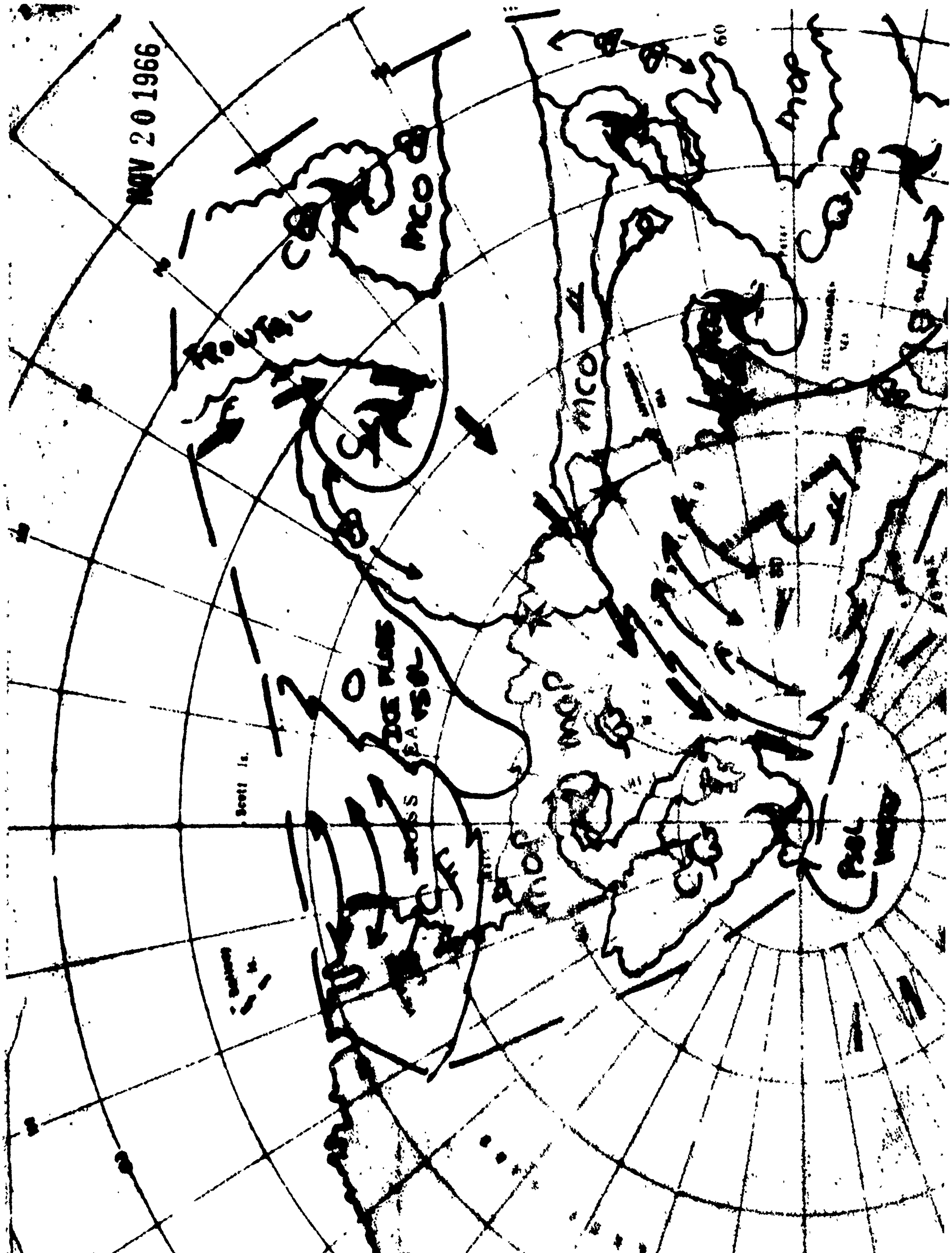
MCO
OPEN CELLS
ROSS SEA
Scott Is
MCO
MOP
CIRRUS VEILS
WAVE CLOUDS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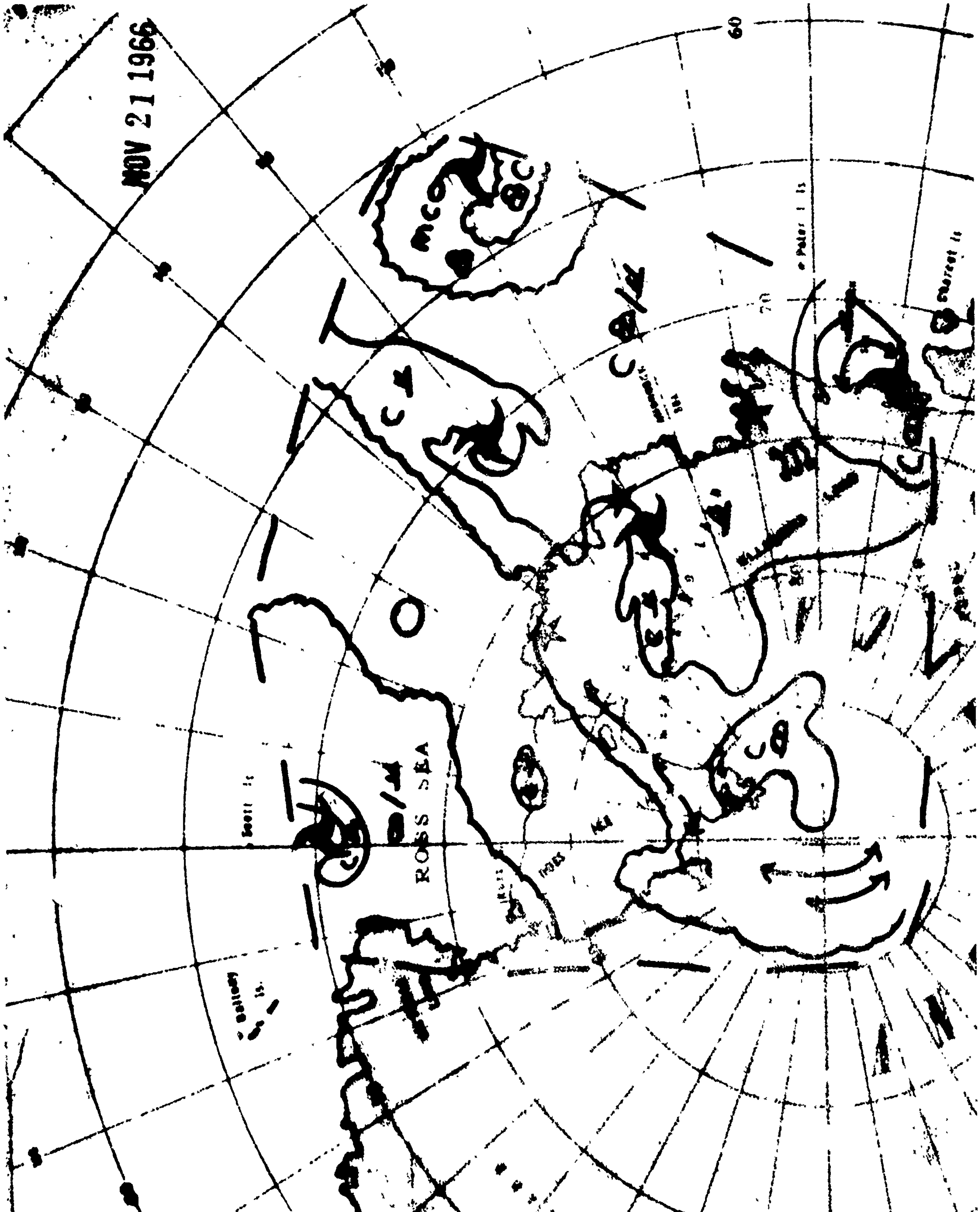
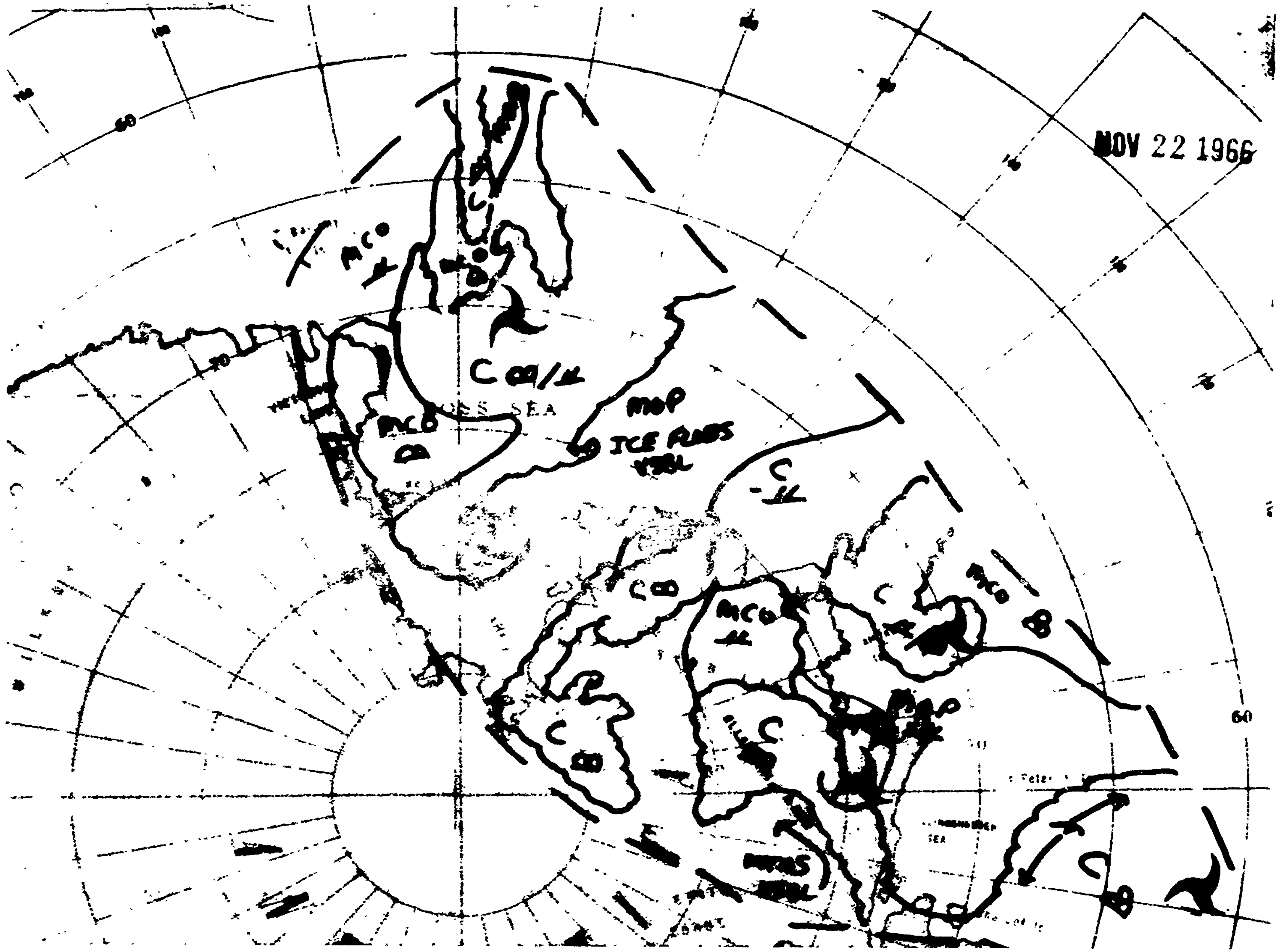
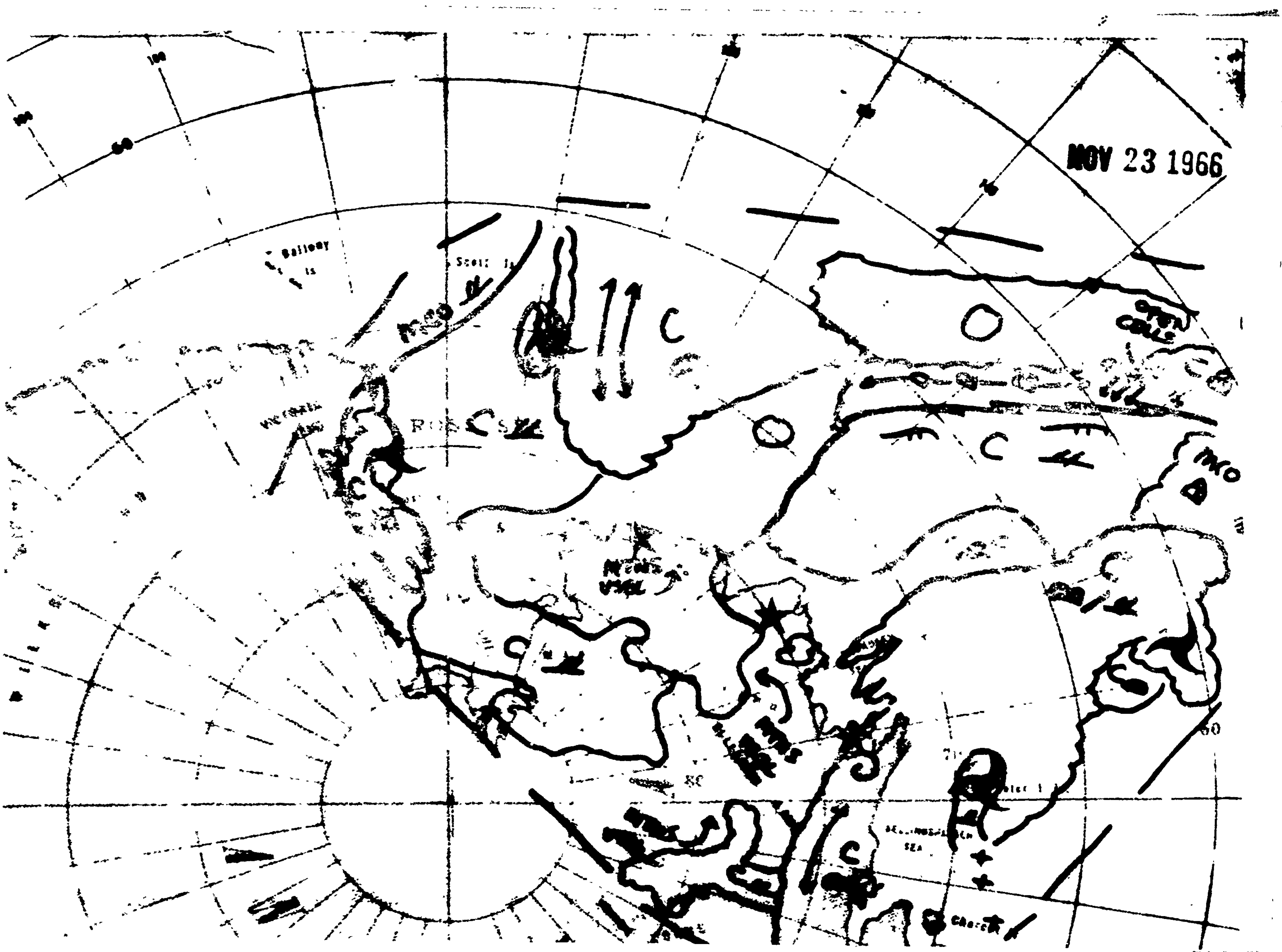
MCO
Scott Is.
ROSS



NOV 21 1966
60
Peter I Is
Scott Is
ROSS SEA
Balleny Is



NOV 22 1966
ICE FLOES
SEA
60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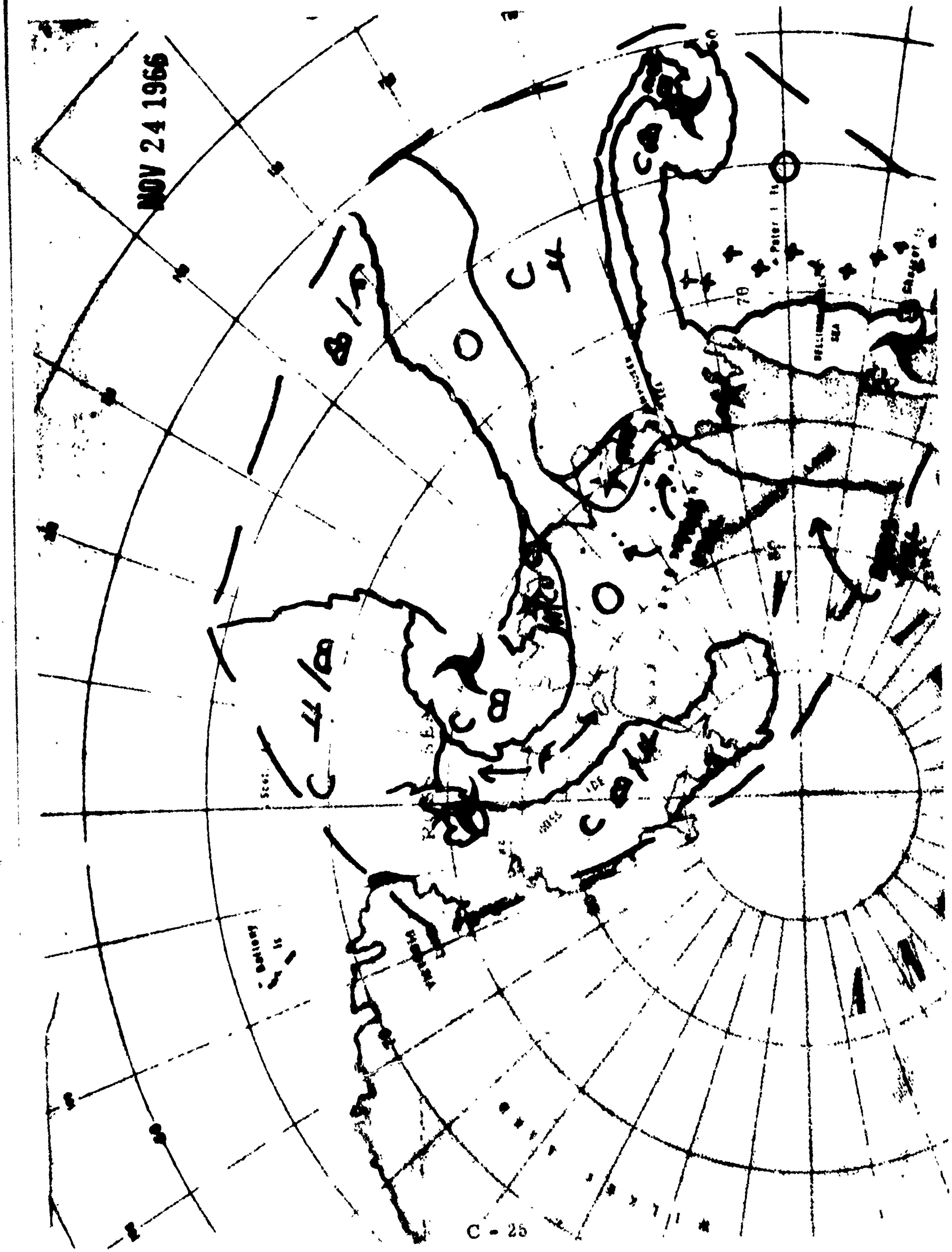
OPEN CELLS
Balleny Is
Scott Is
Ross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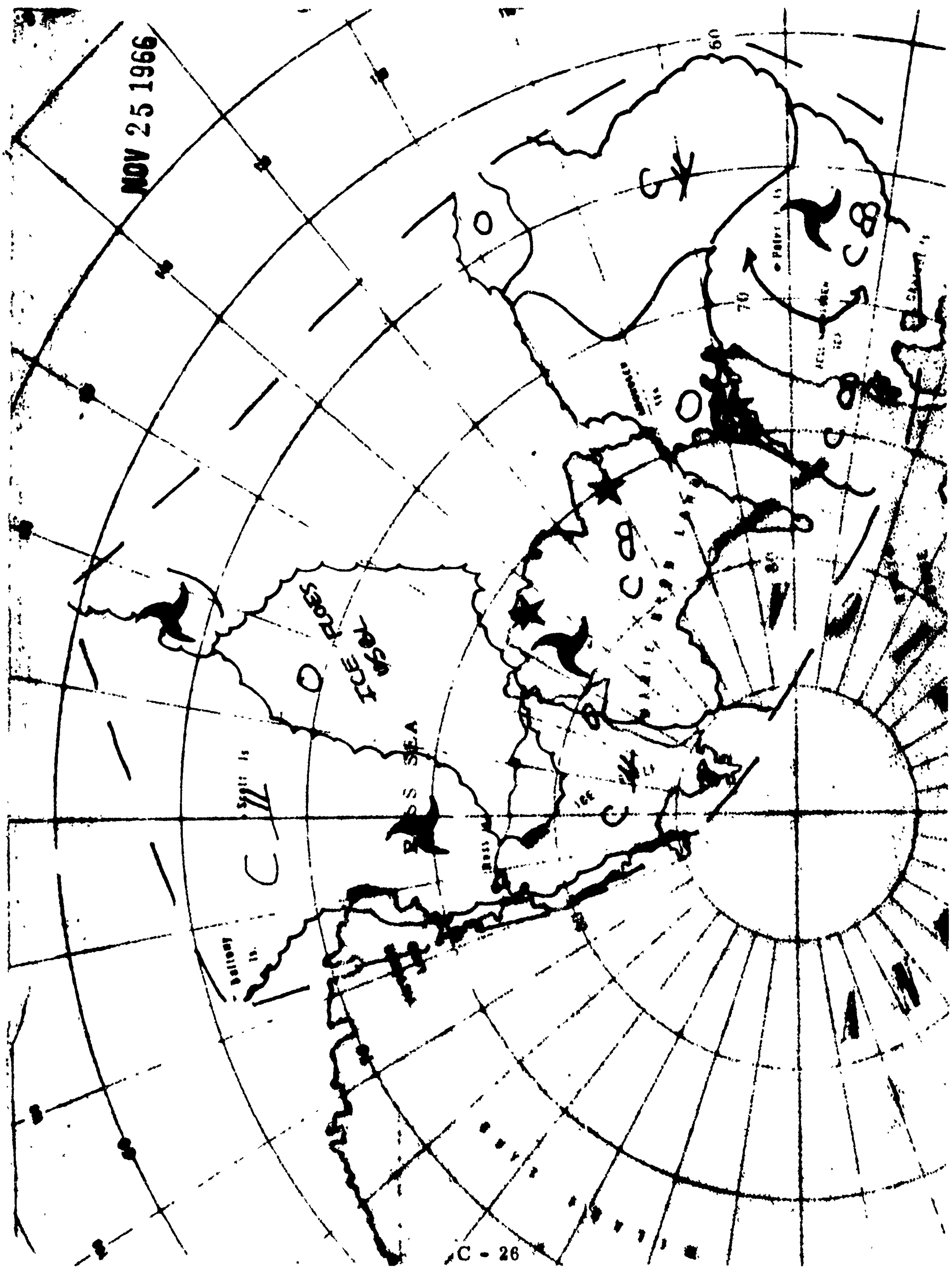
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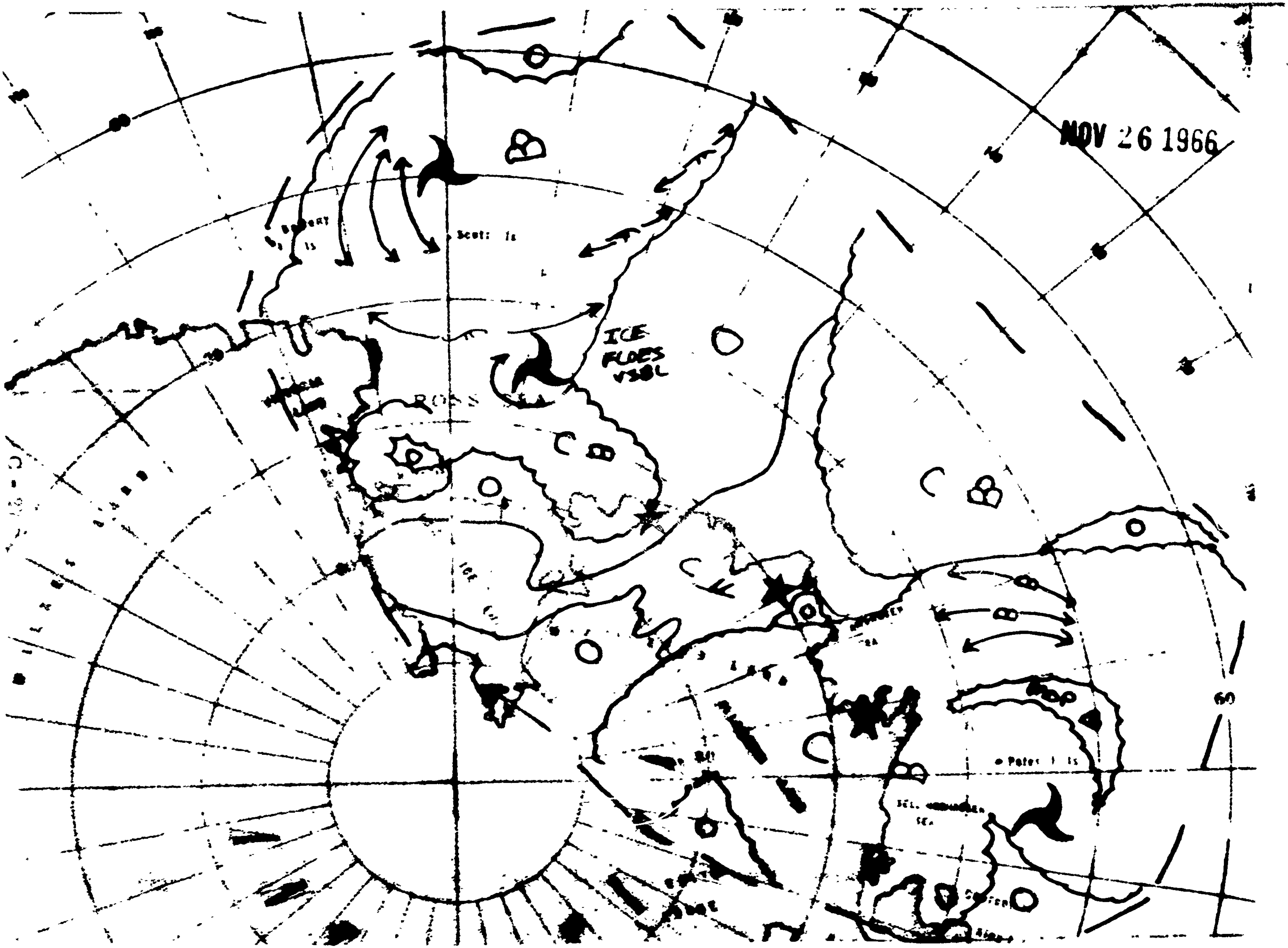
ICE FLOES
ROSS SEA
Scott Is
Balleny Is.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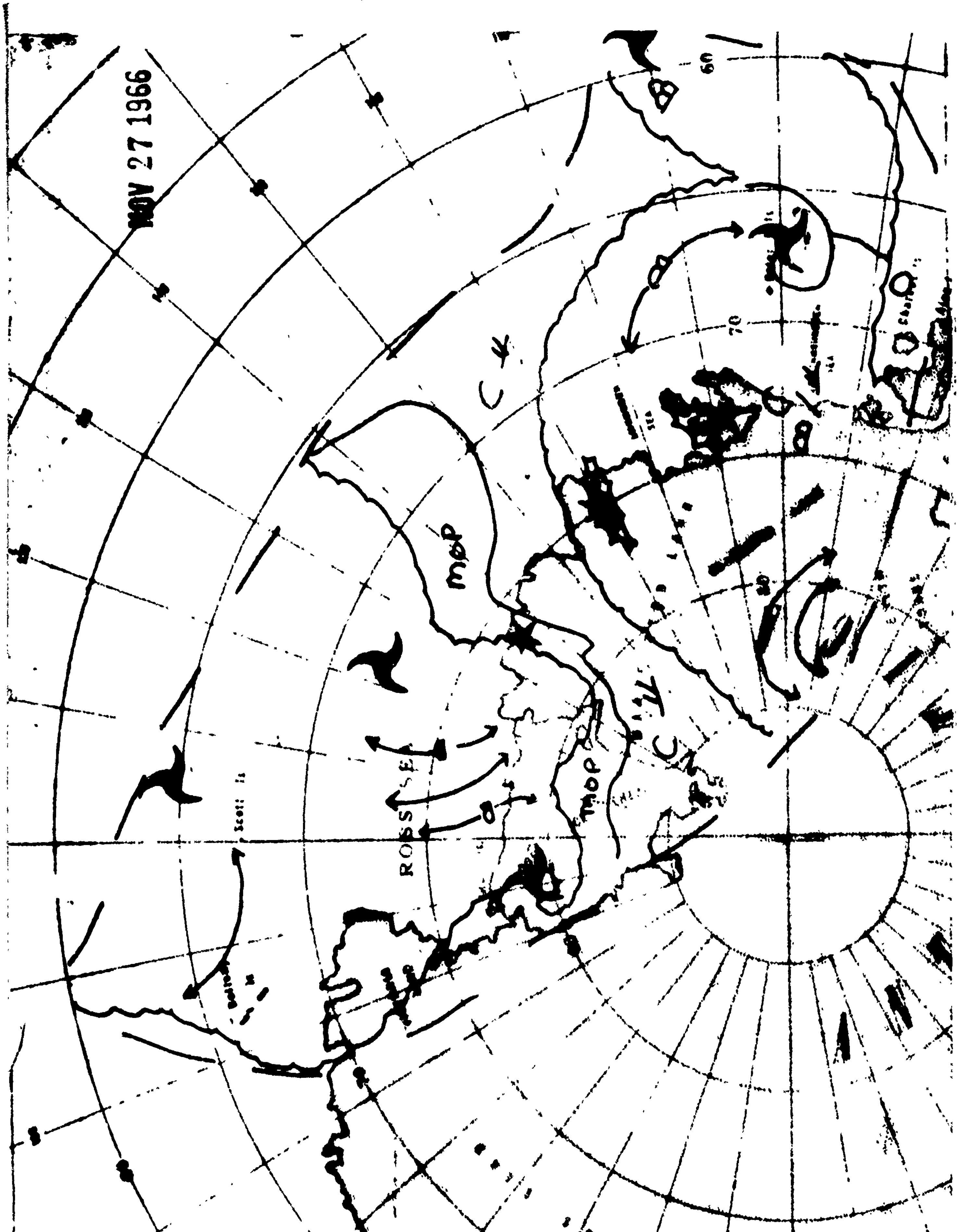
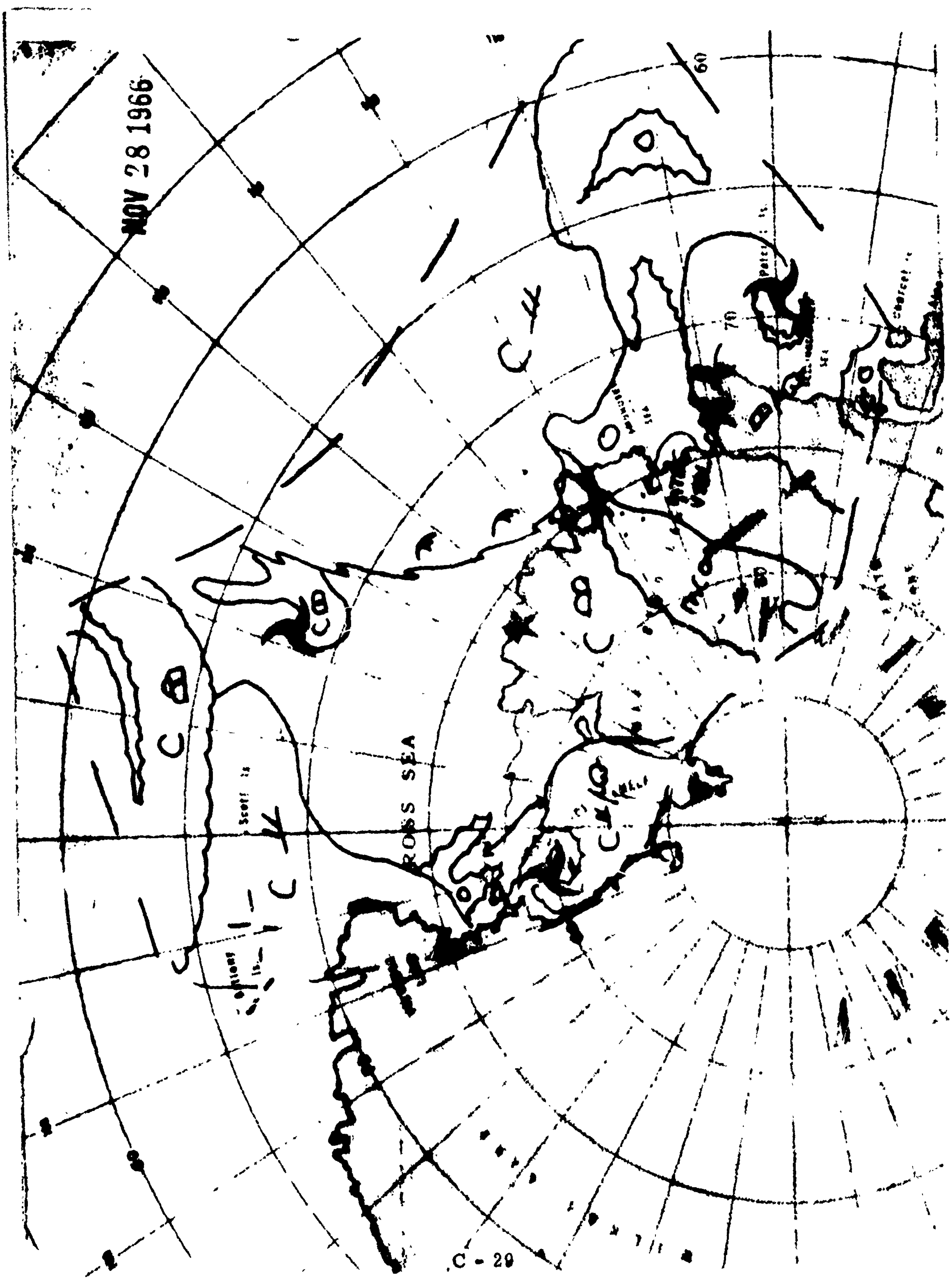
ICE
FLOES
VSBL
Scott Is
ROSS
Peter I Is
60


NOV 27 1966
ROSS
60
70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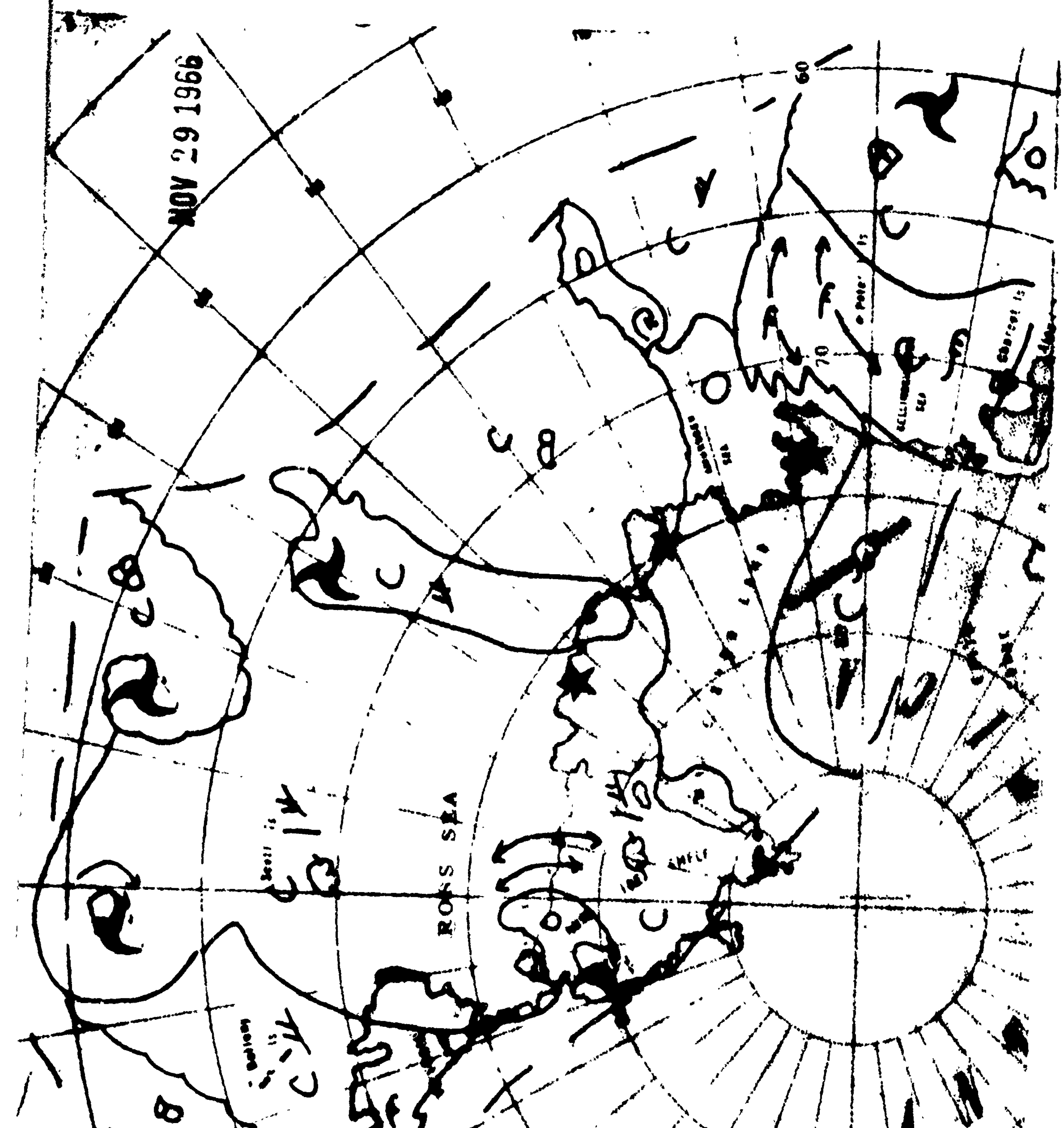
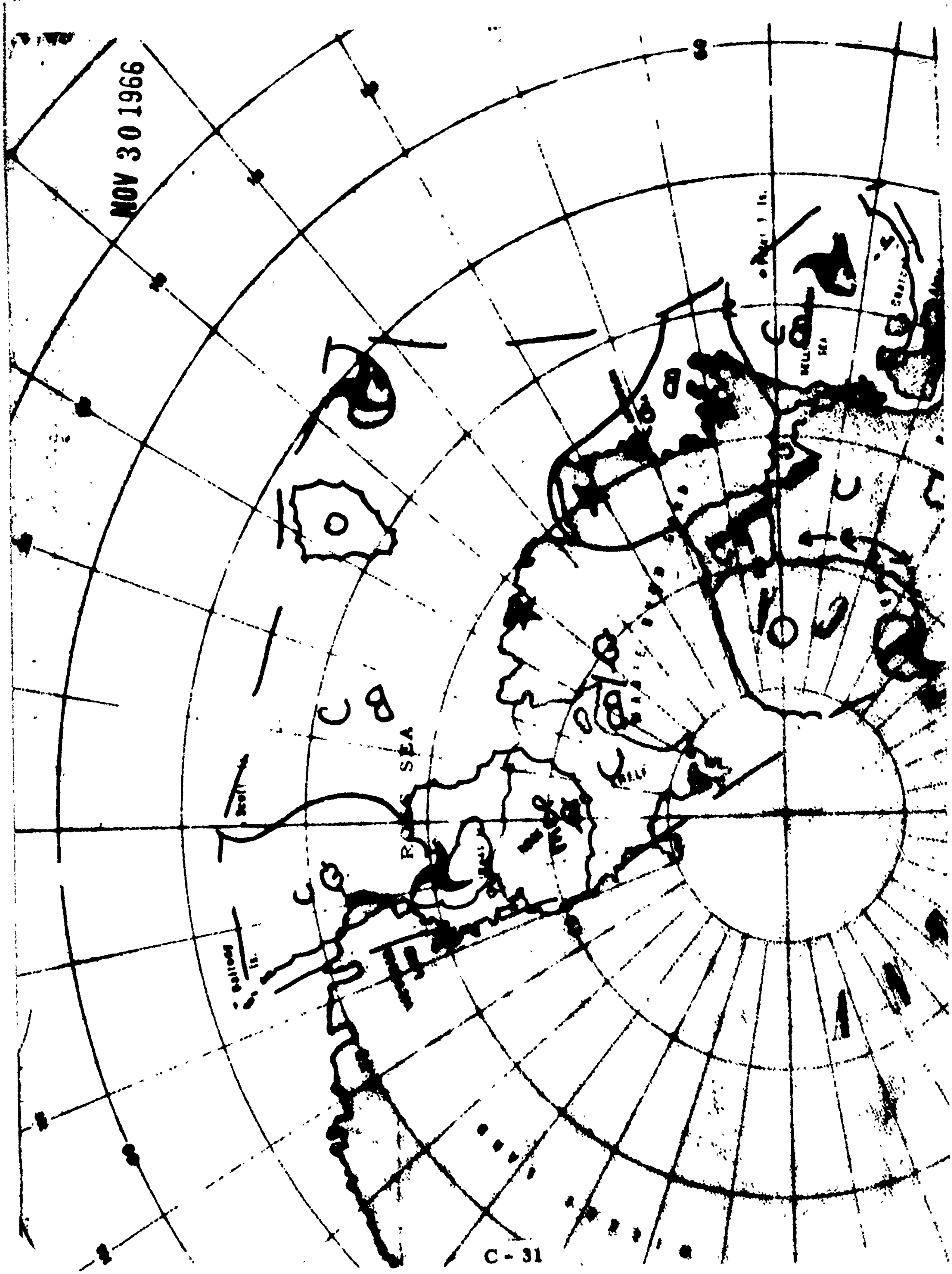
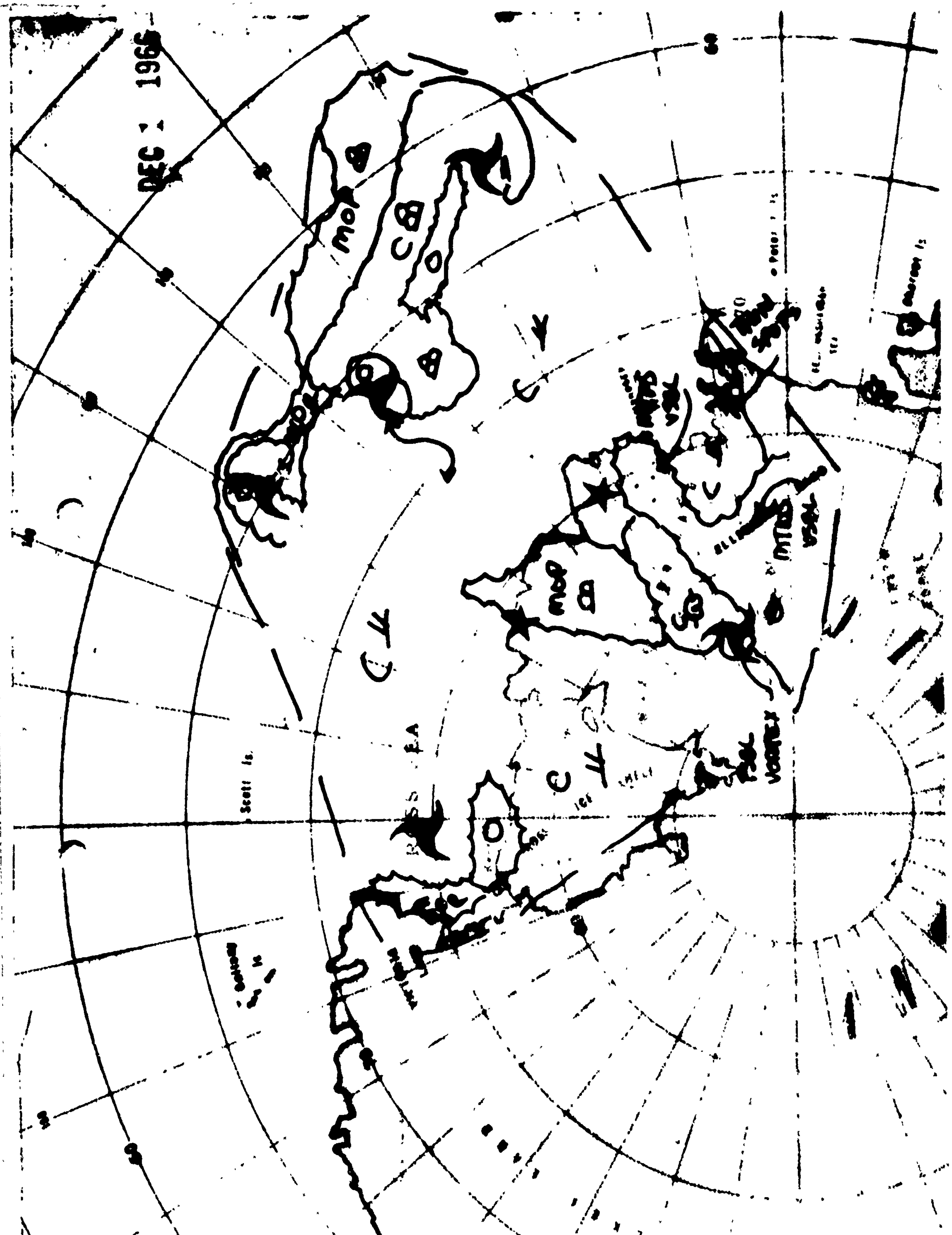

NOV 29 1966
ROSS SEA

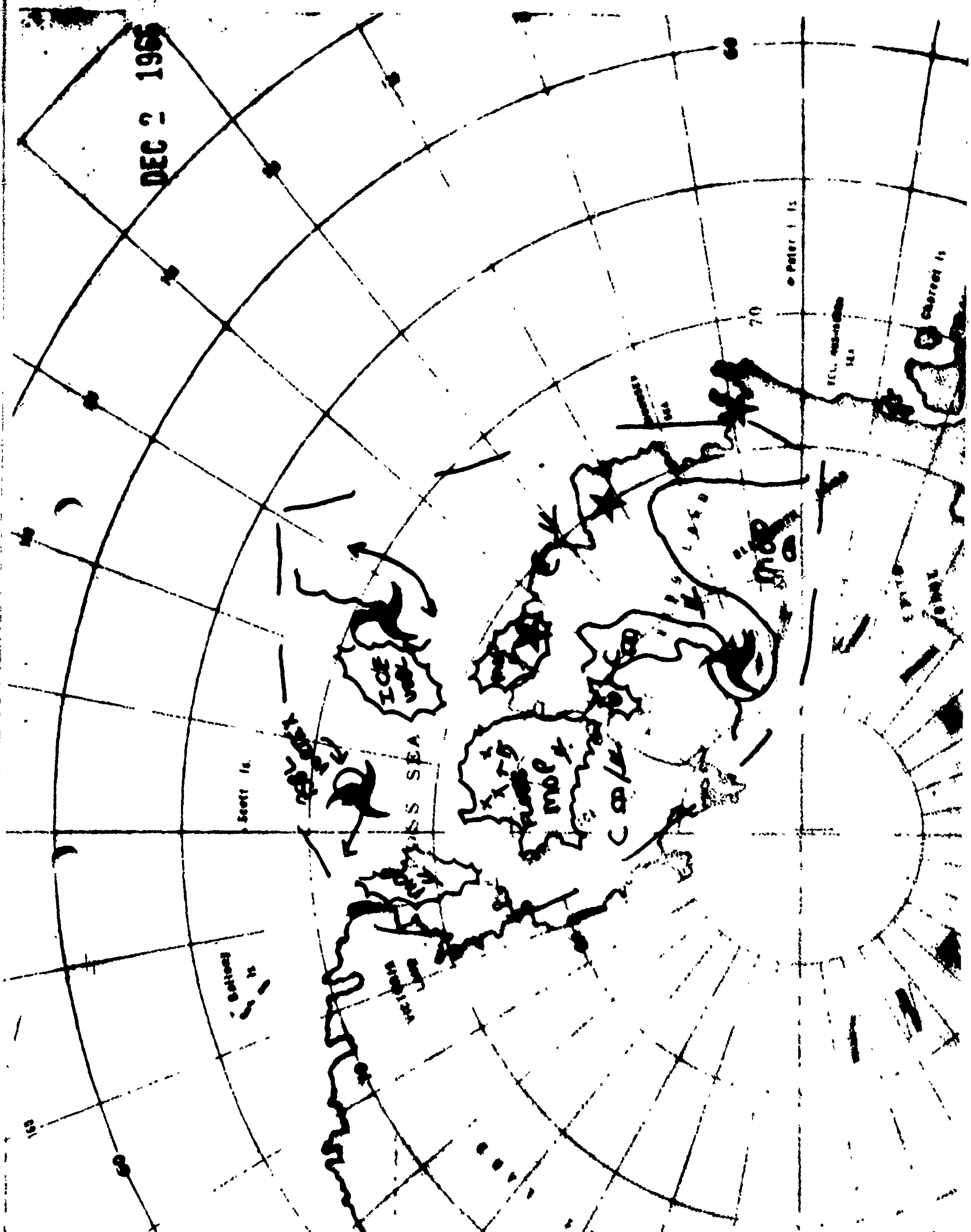

NOV 30 1966
SEA
Balleny
Is.

APPENDIX D

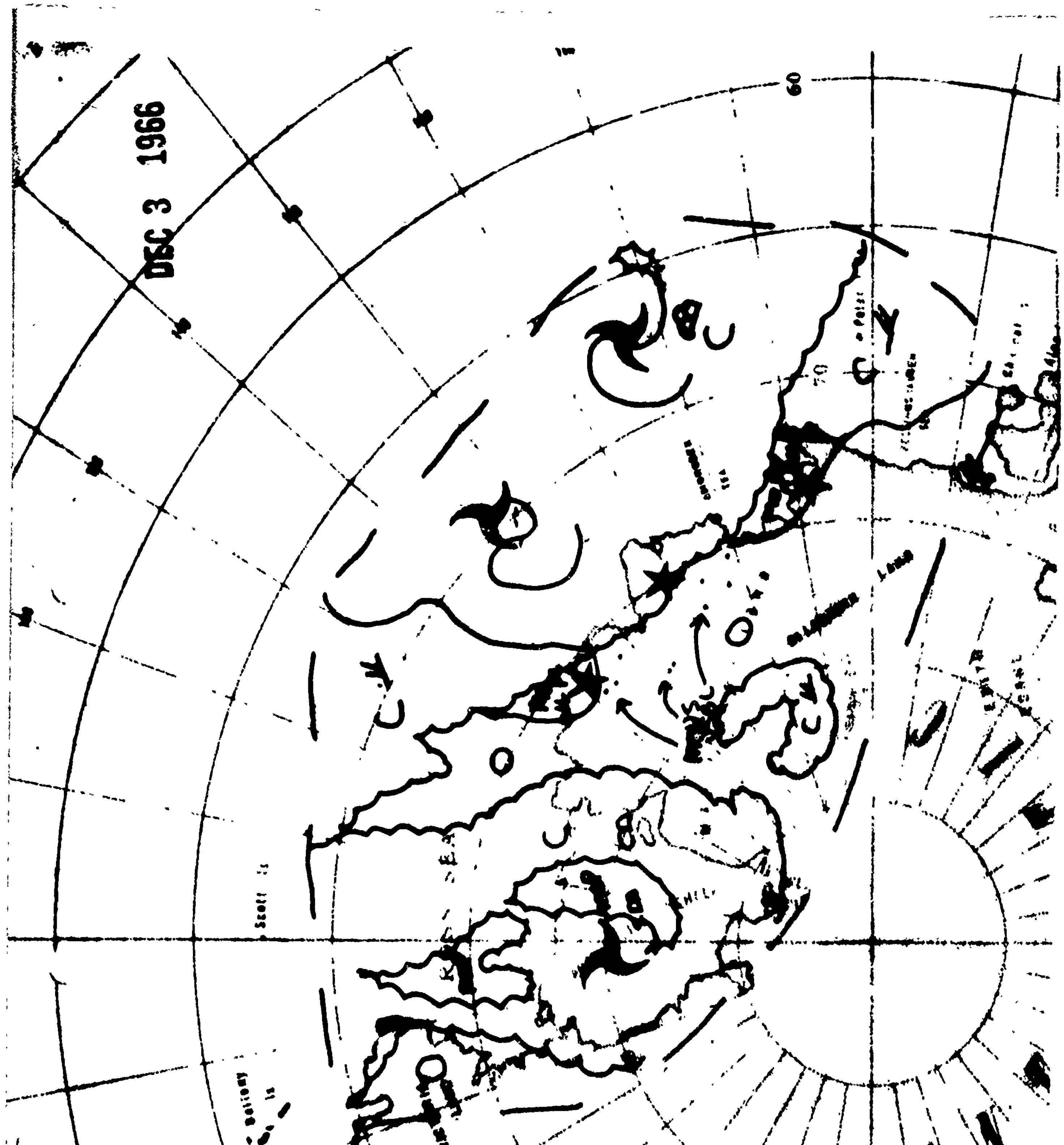
DECEMBER 1966 NEPHANALYSES

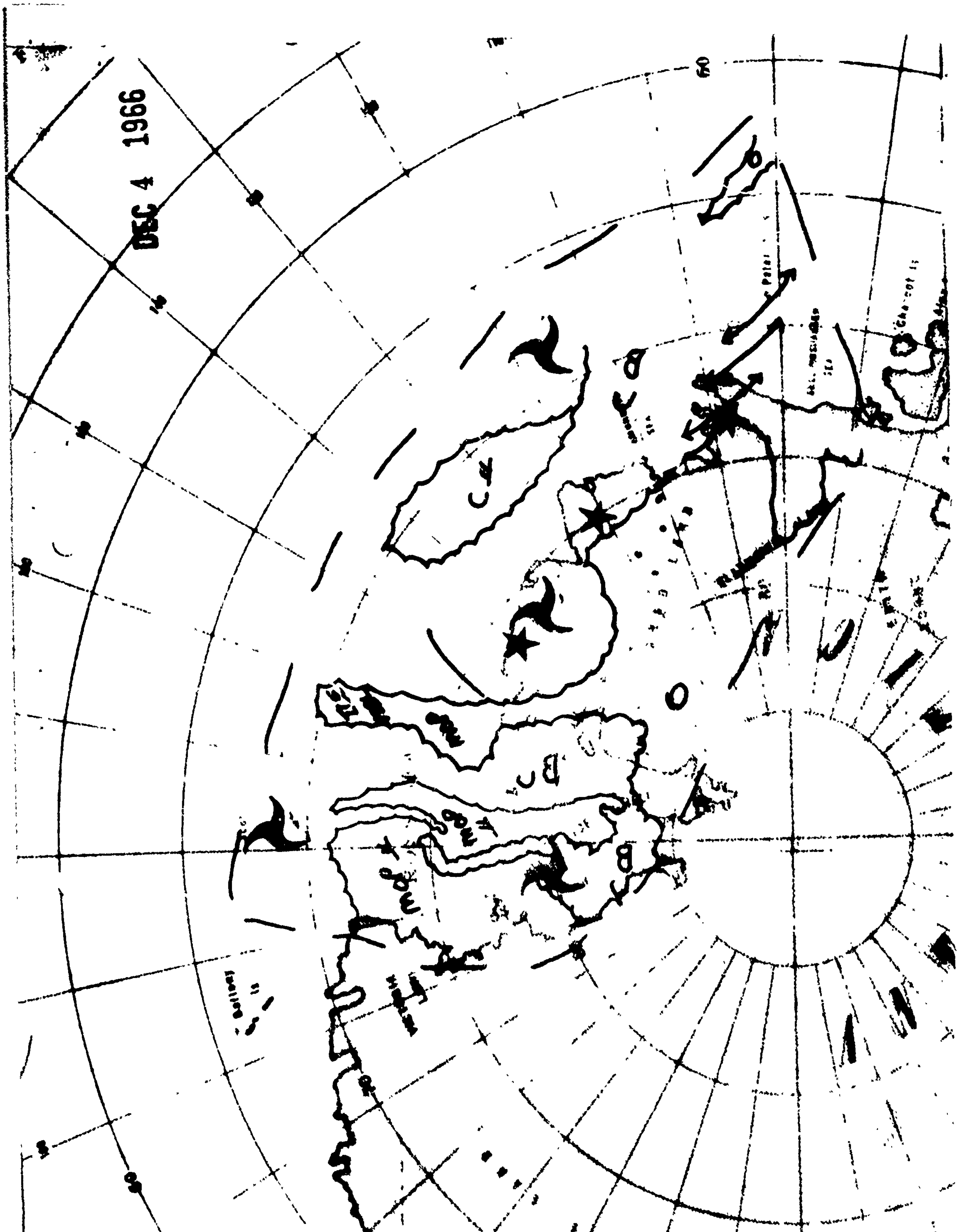


DEC 1966
MOB
CB
MTNS VSBL
Scott Is.
POLAR VORTEX



SS SEA
Scott Is
Peter I Is
70


DEC 3 1966
60
70
Scott Is
Balleny Is


DEC 4 1966
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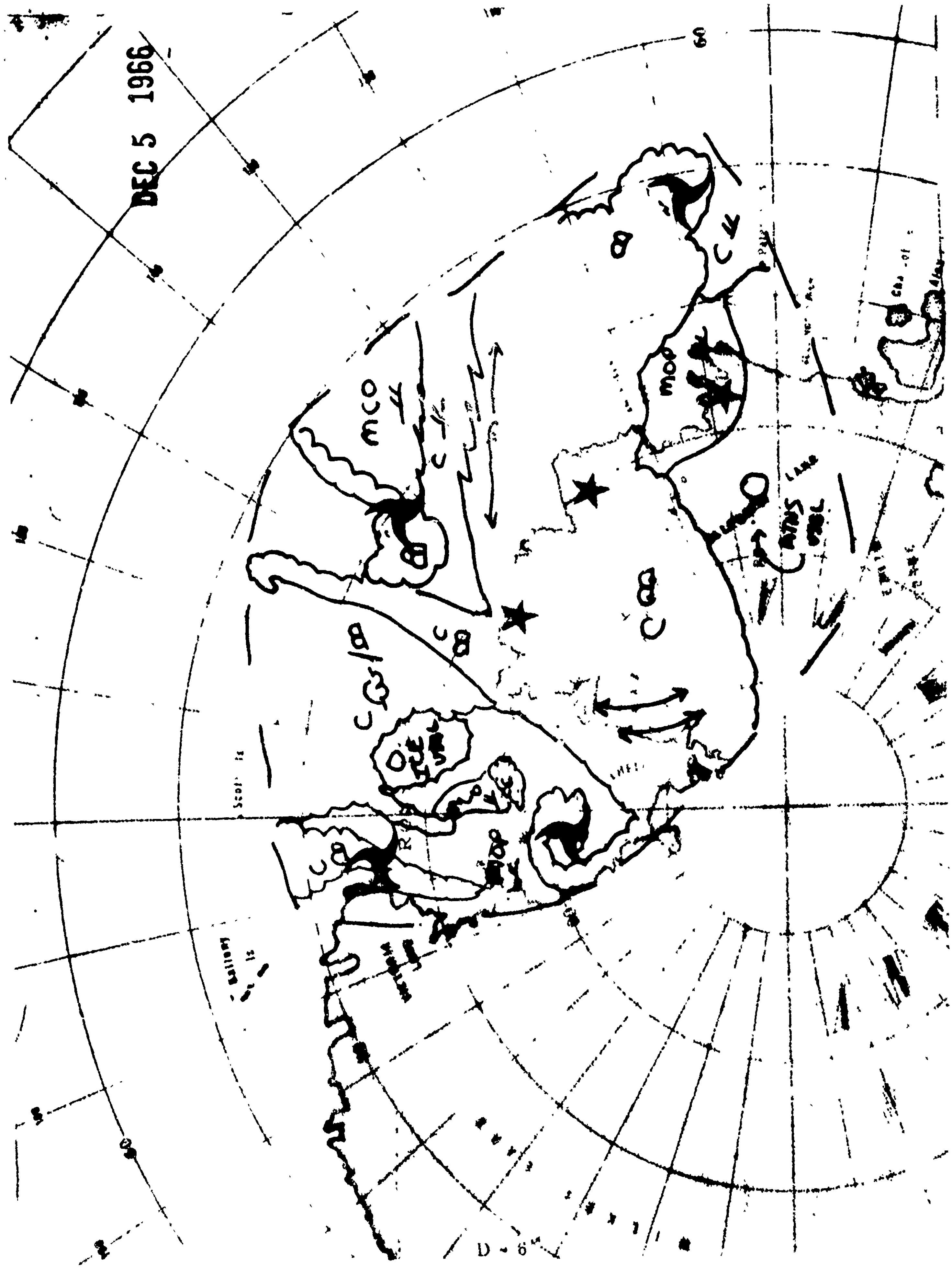
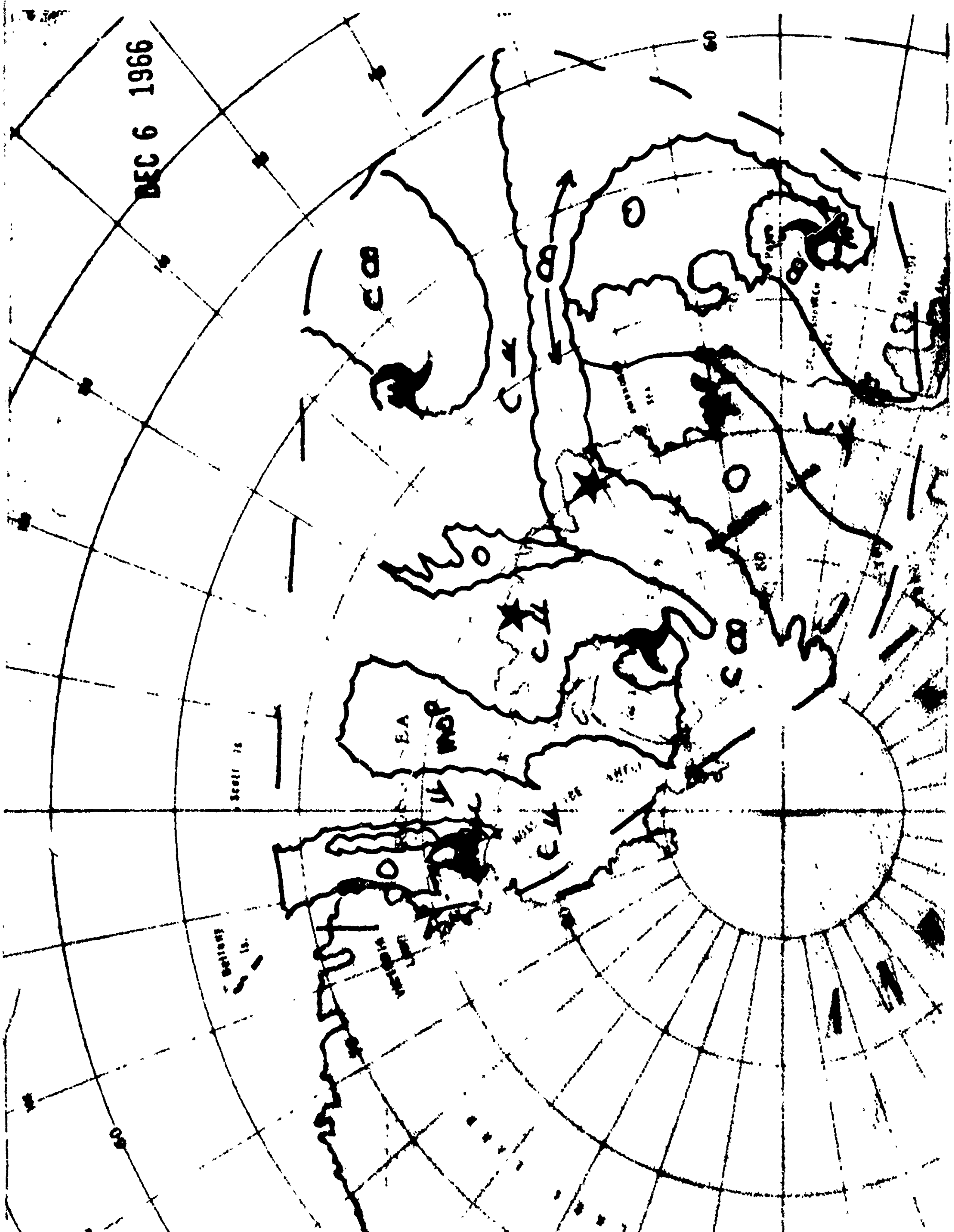
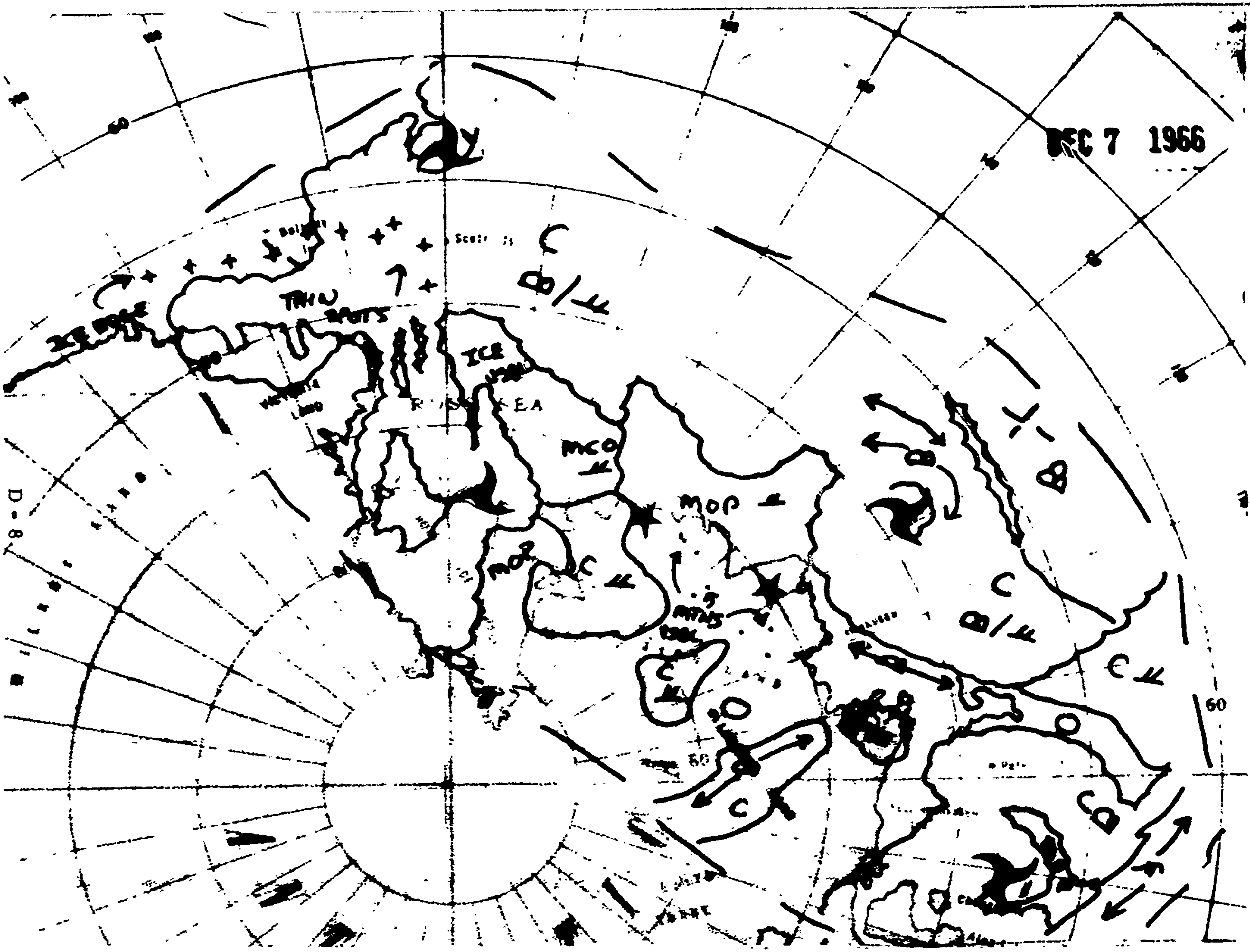
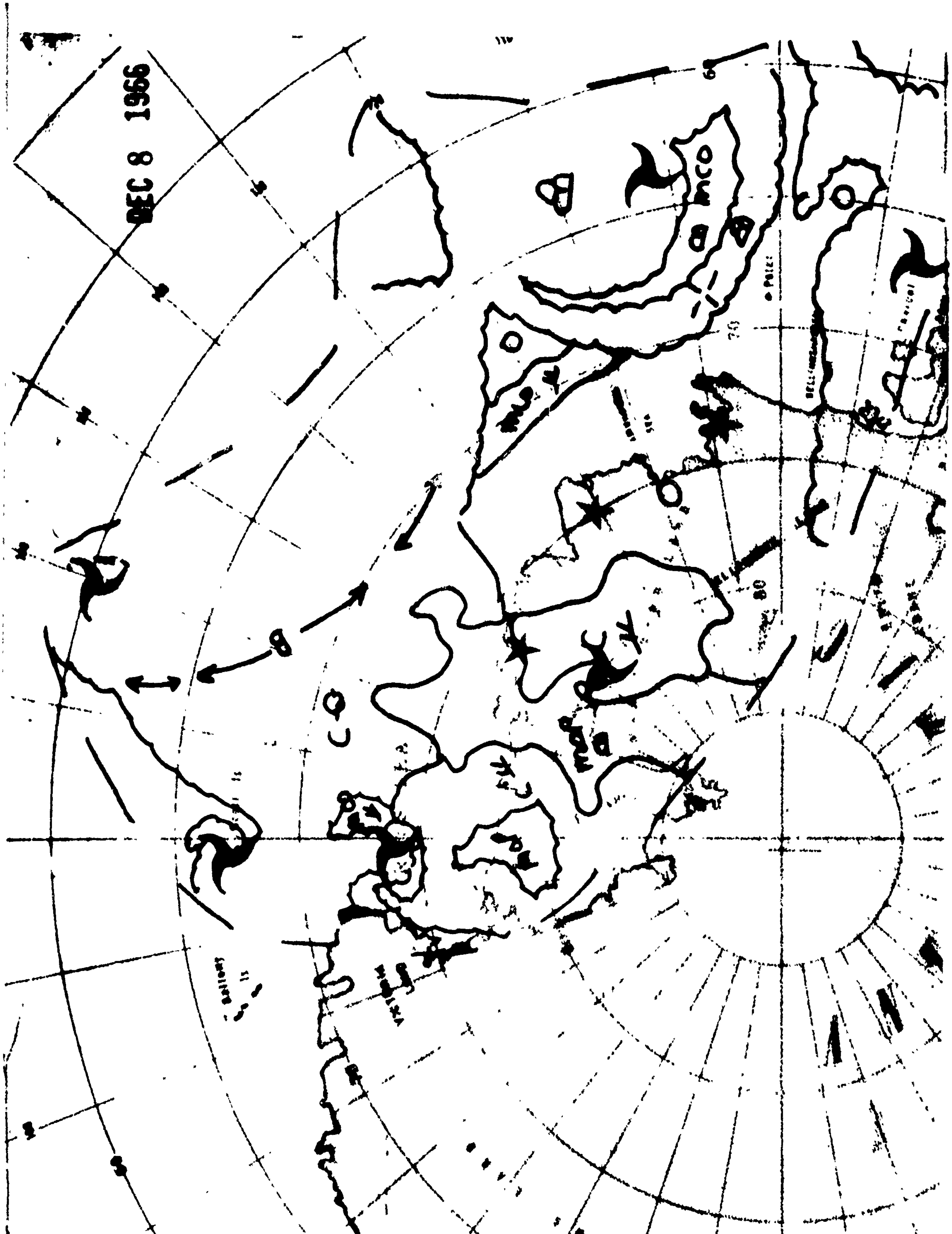
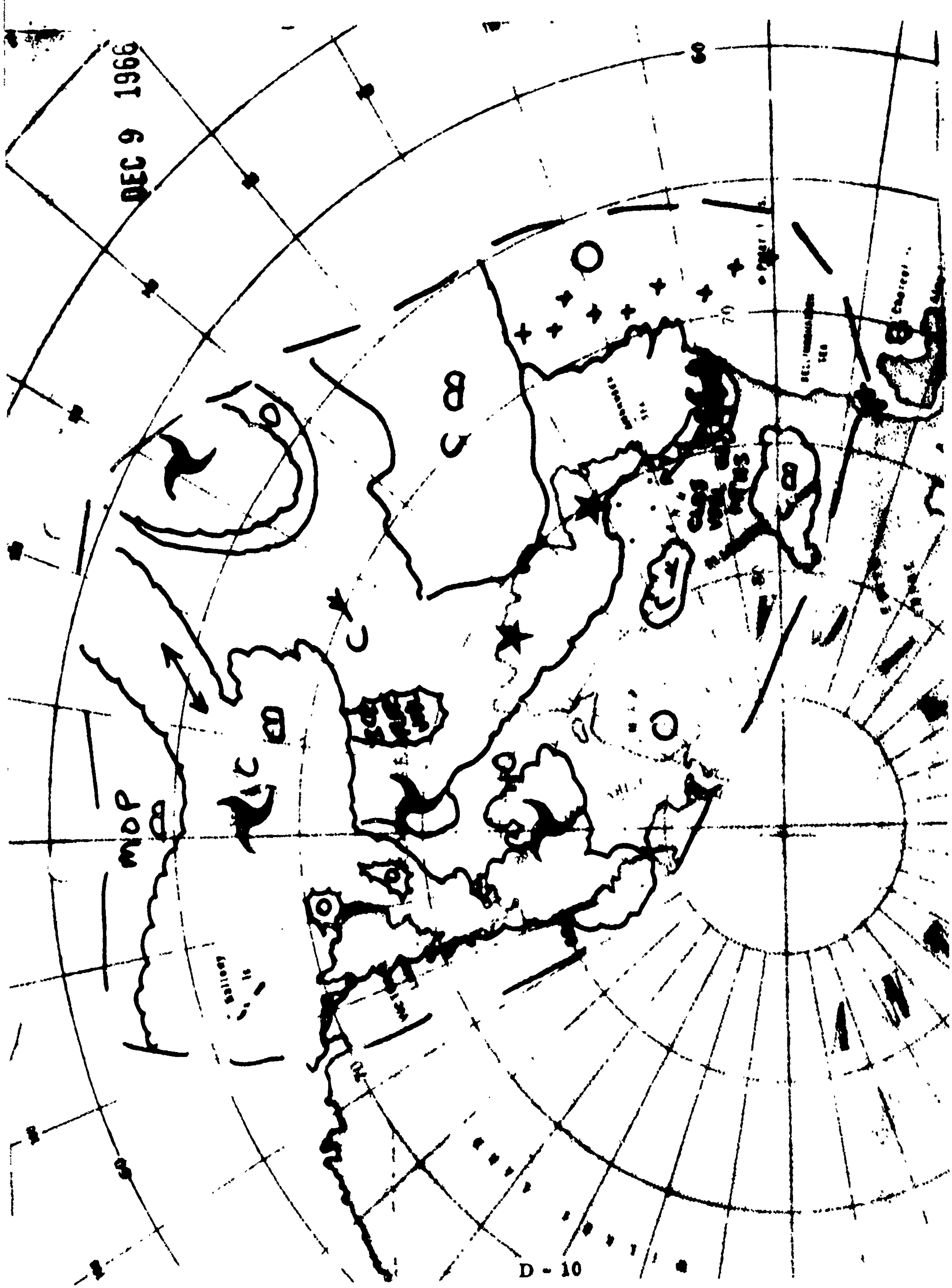
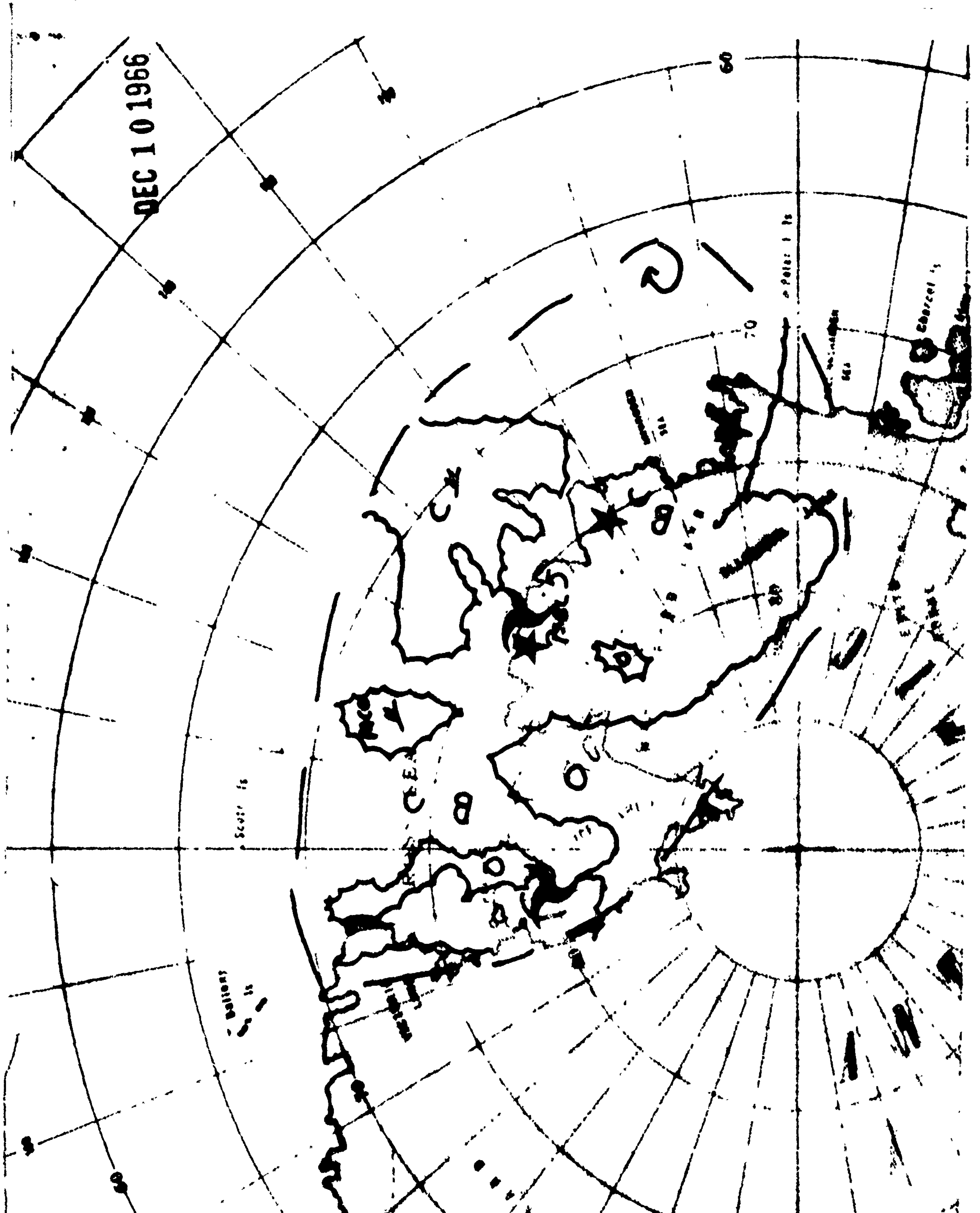

DEC 5 1966

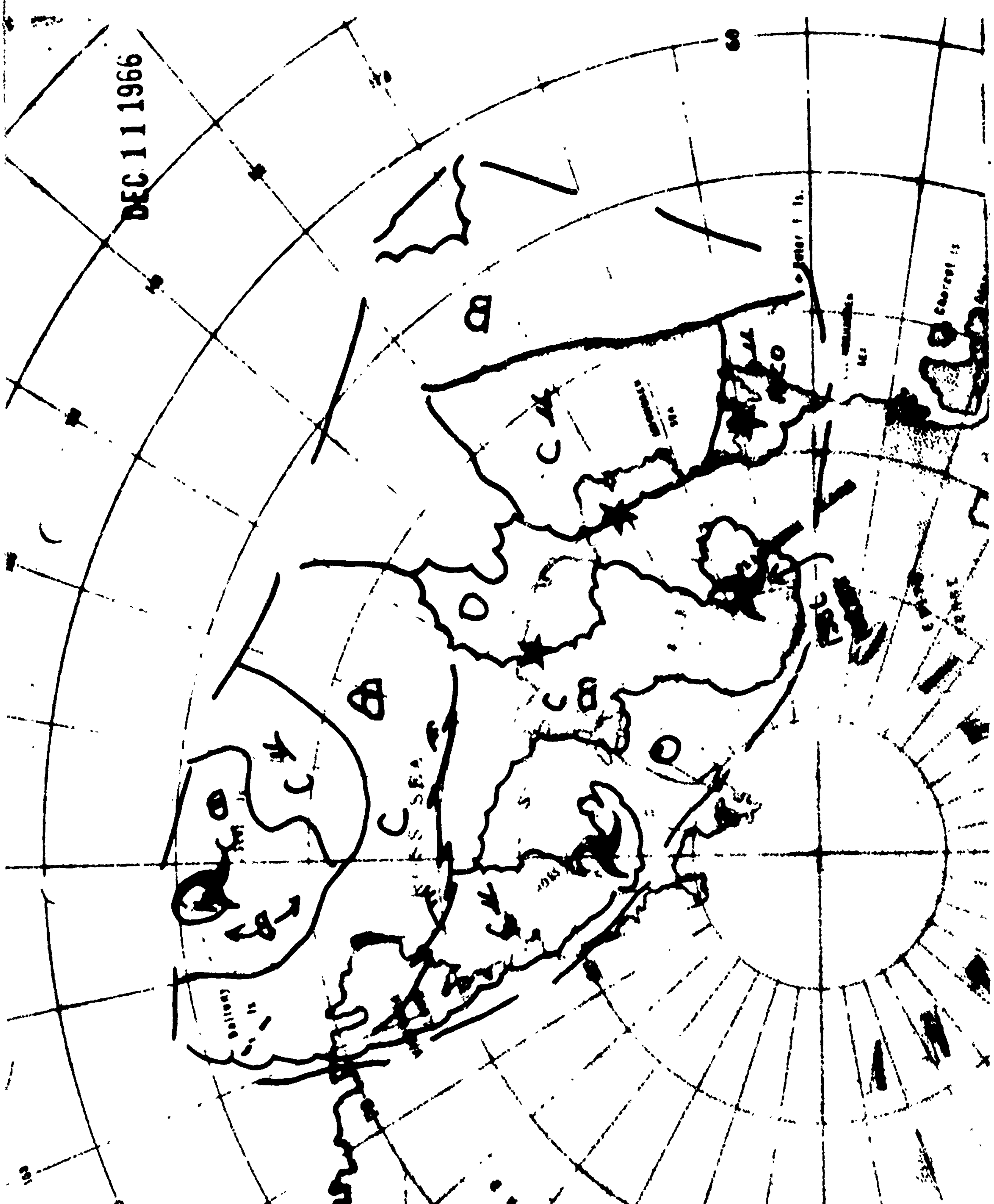

DEC 6 1966
Scott Is.
Balleny Is.
60
60


DEC 7 1966
ICE EDGE
THIN SPOTS
ICE
ROSS SEA
Scott Is
Balleny Is
VICTORIA LAND
C
CB/K
MCO K
MOP K
MOP
C K
C
60
CB/K
C K
CB
B

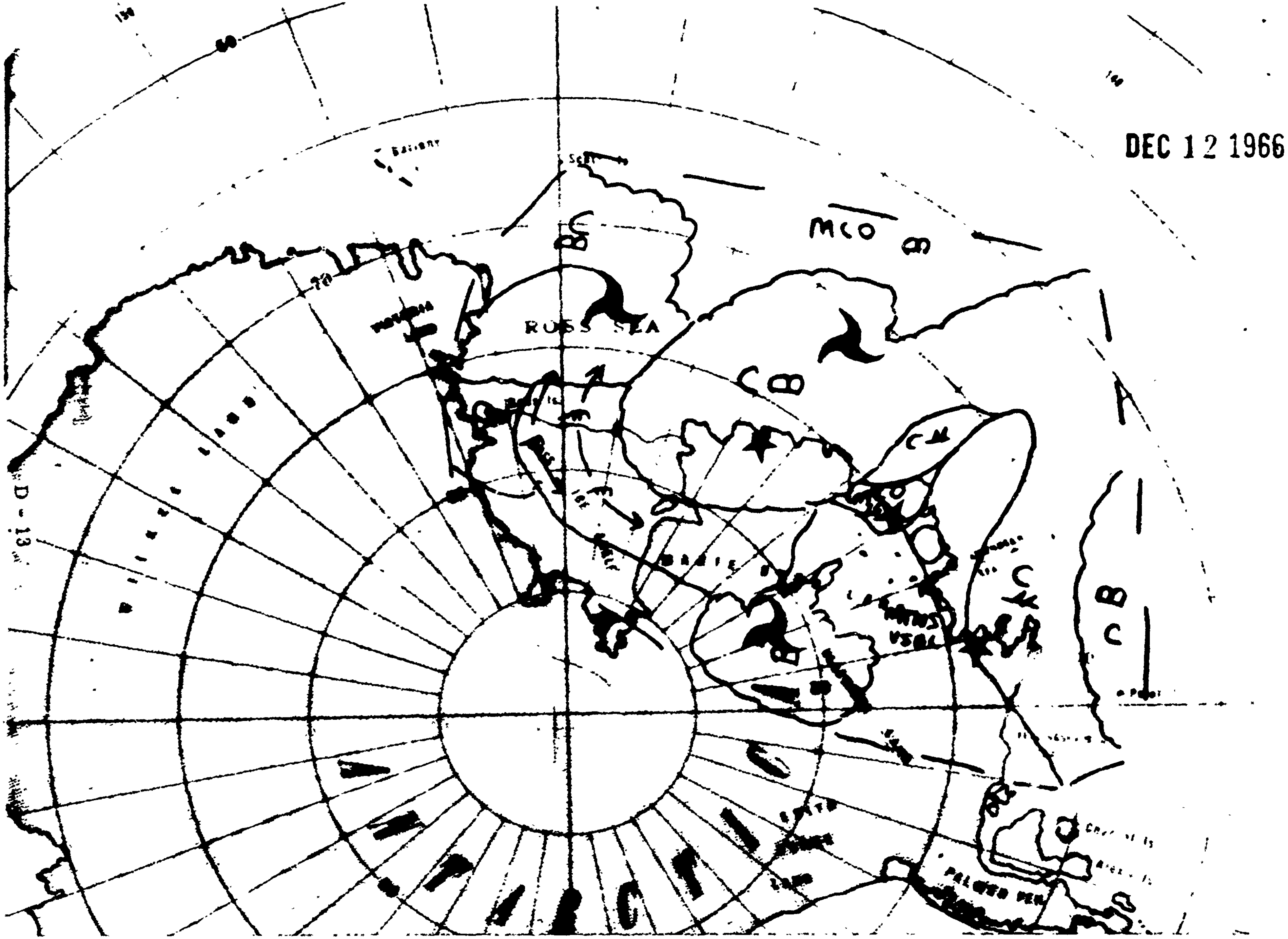

DEC 8 1966
B
C
mcP
mcO
Balleny Is
Victoria Land
80
70
60

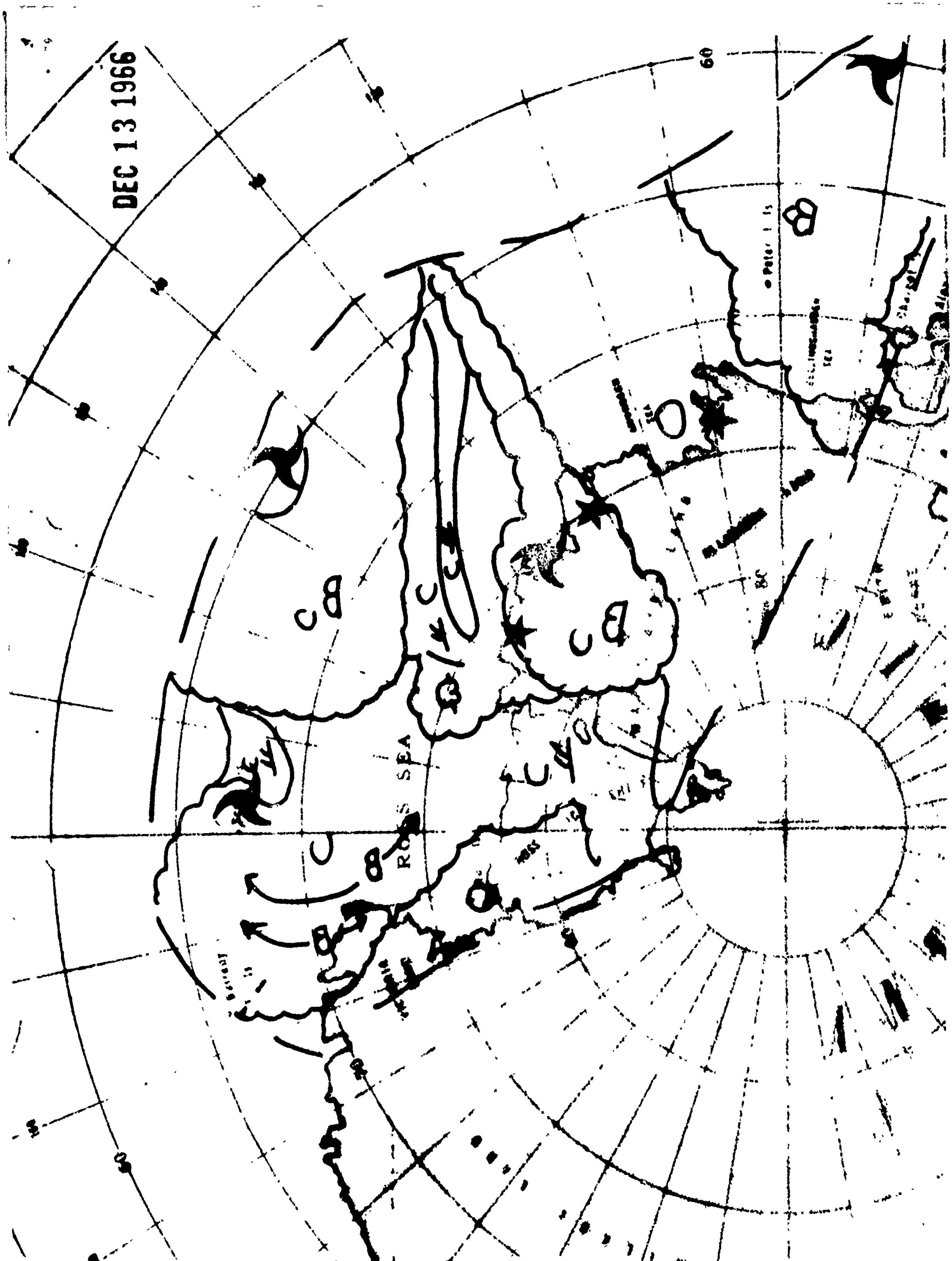

DEC 9 1966
MOP

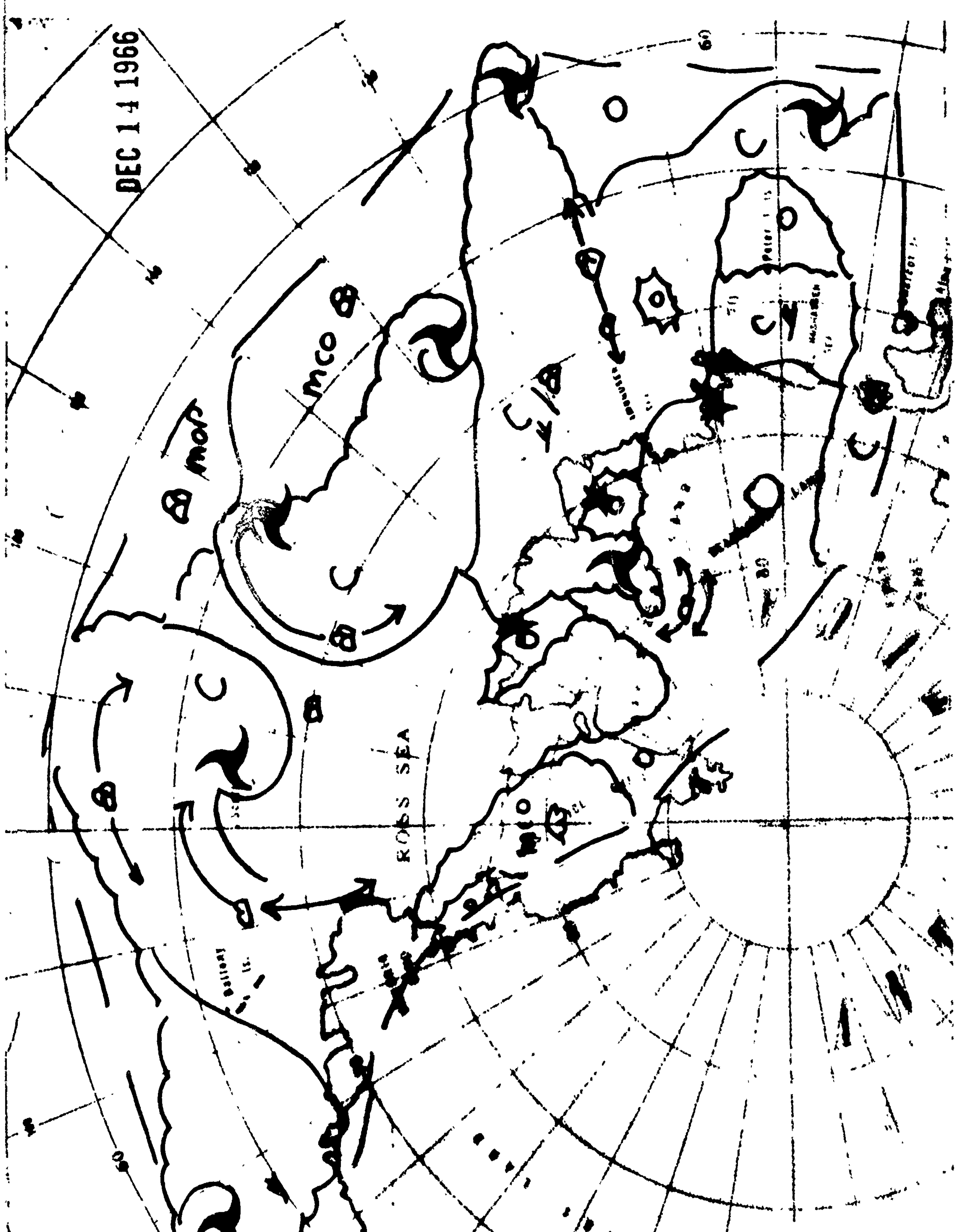



DEC 1 1 1966

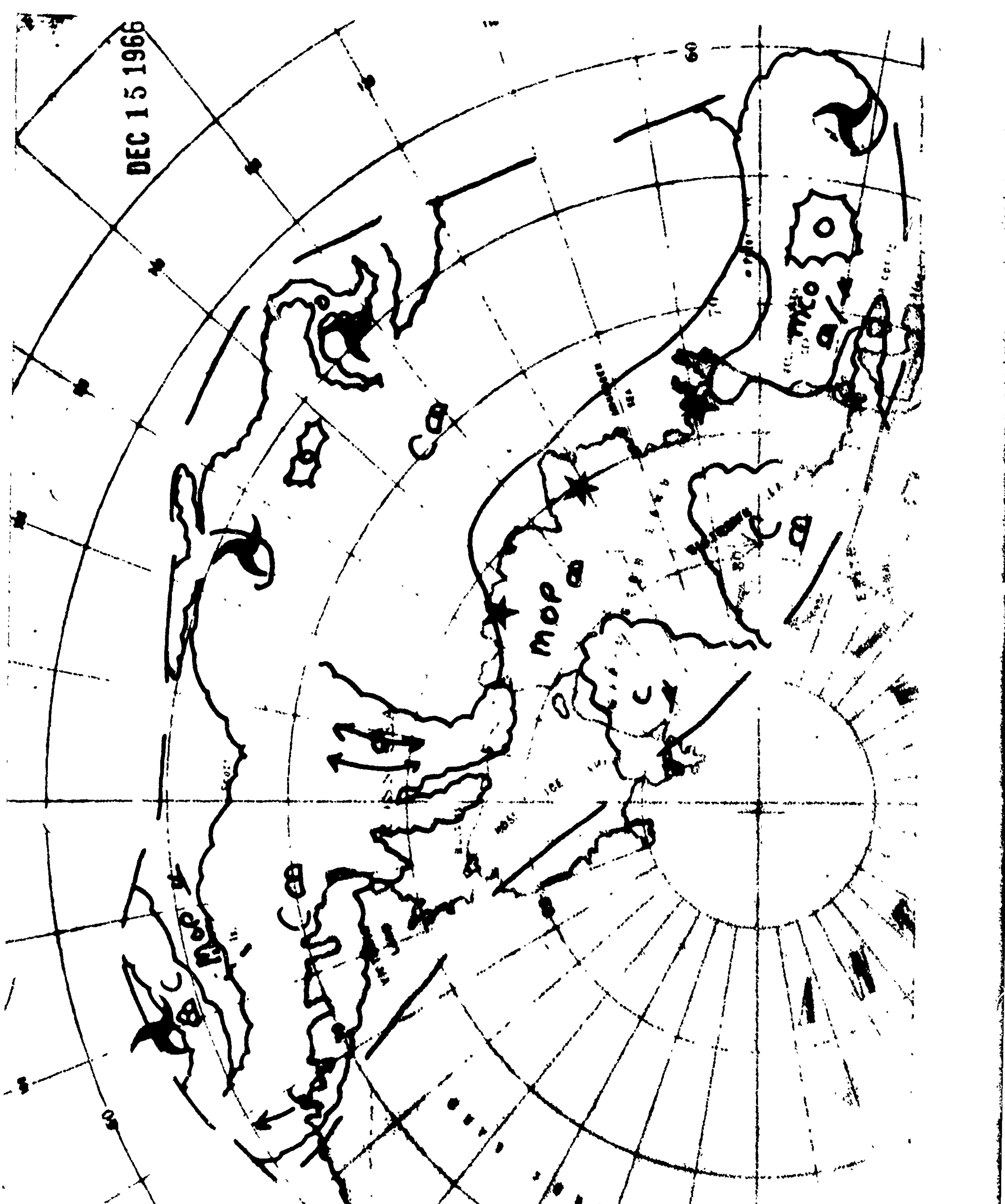
DEC 12 1966

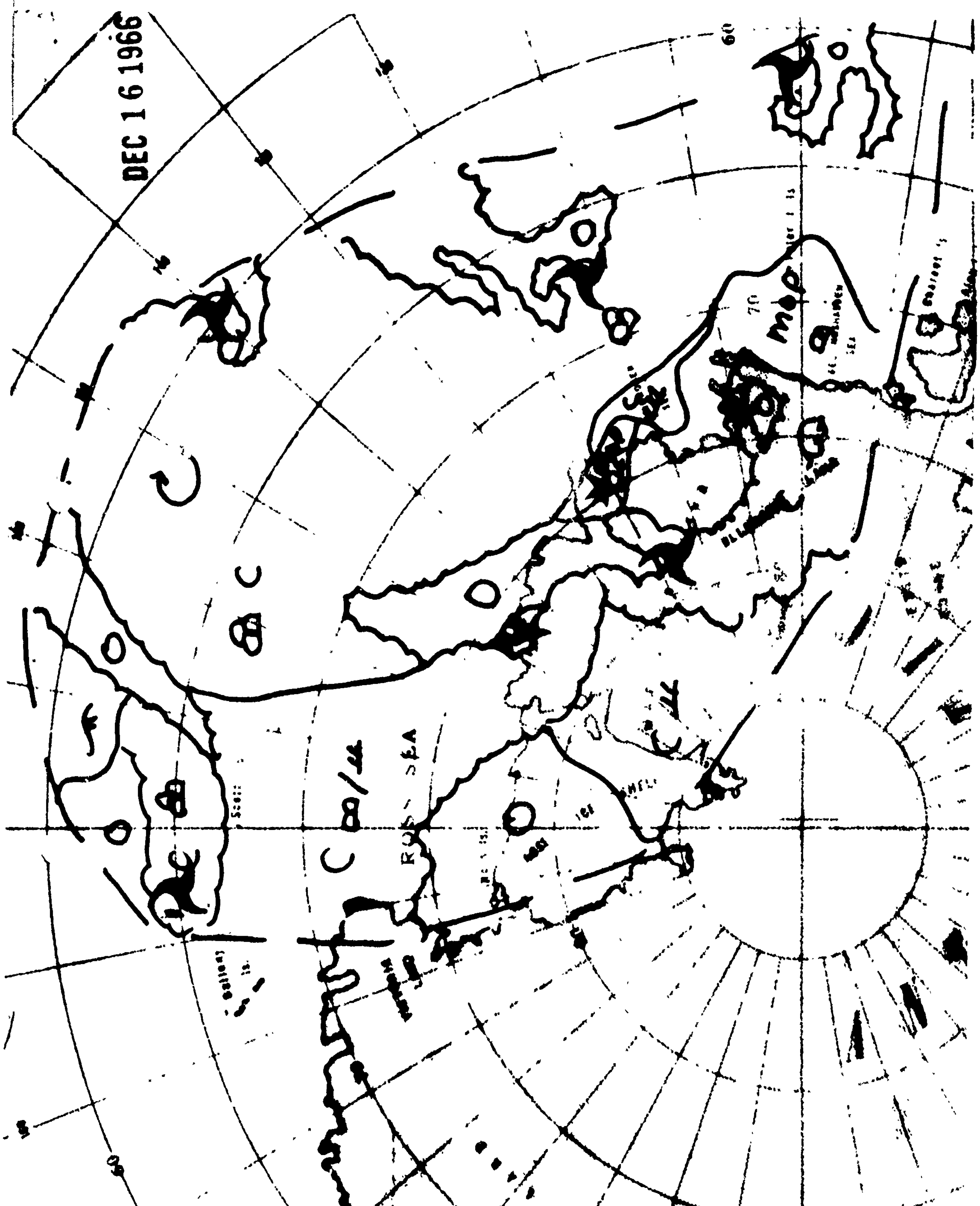


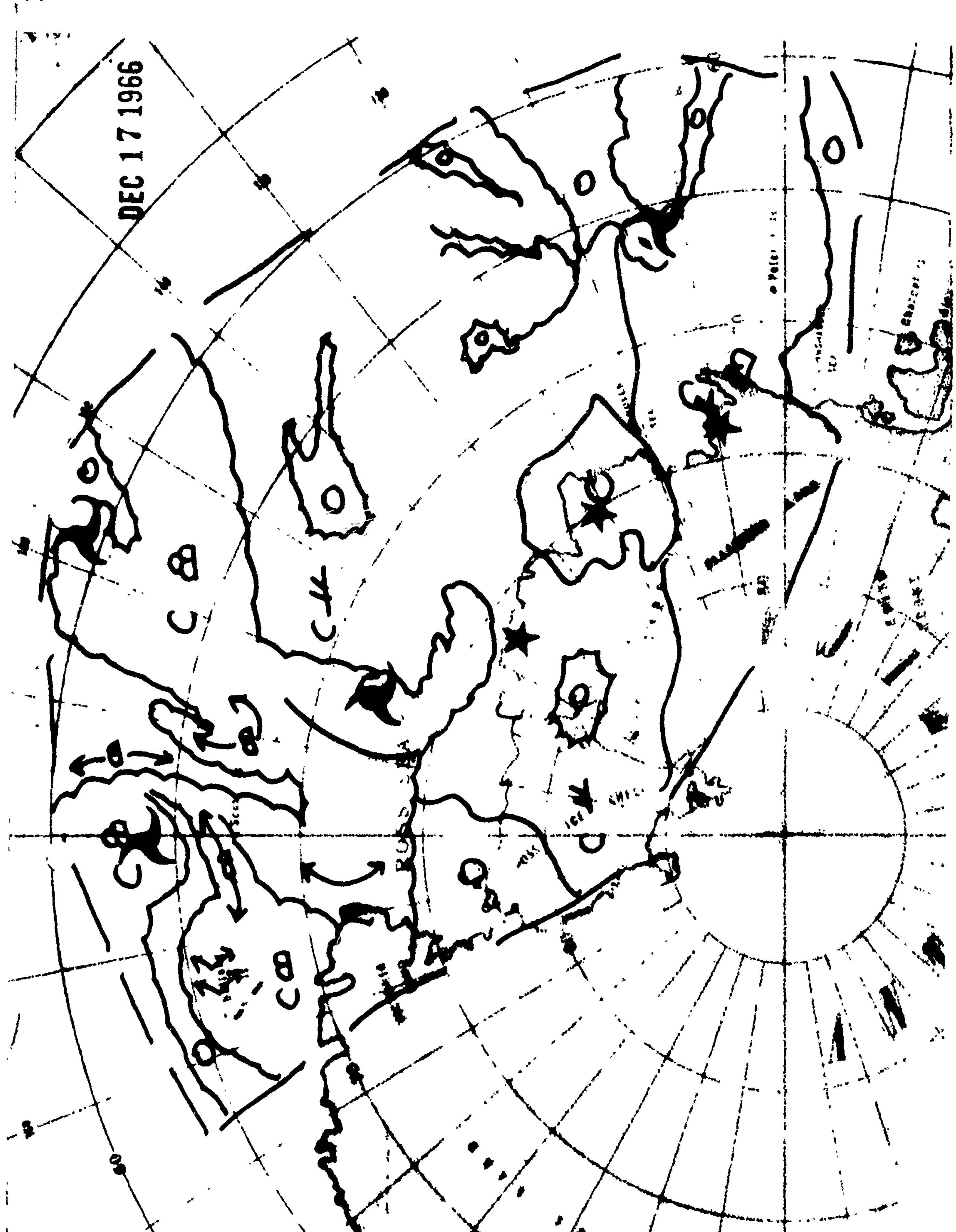

DEC 13 1966
ROSS SEA

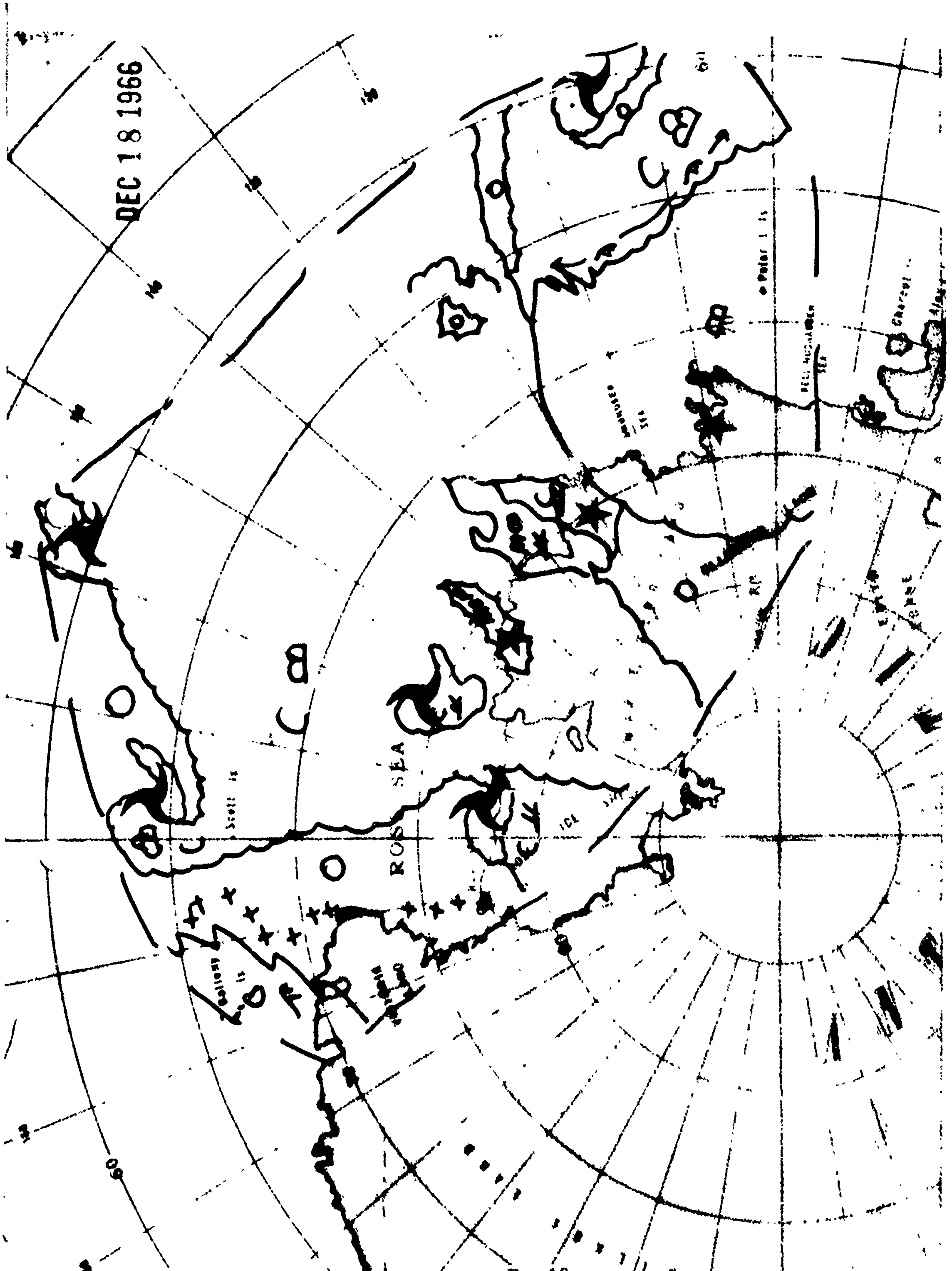


DEC 14 1966
ROSS SEA
mco
mco
Balleny Is.


DEC 15 1966


DEC 16 1966
ROSS SEA


DEC 17 1966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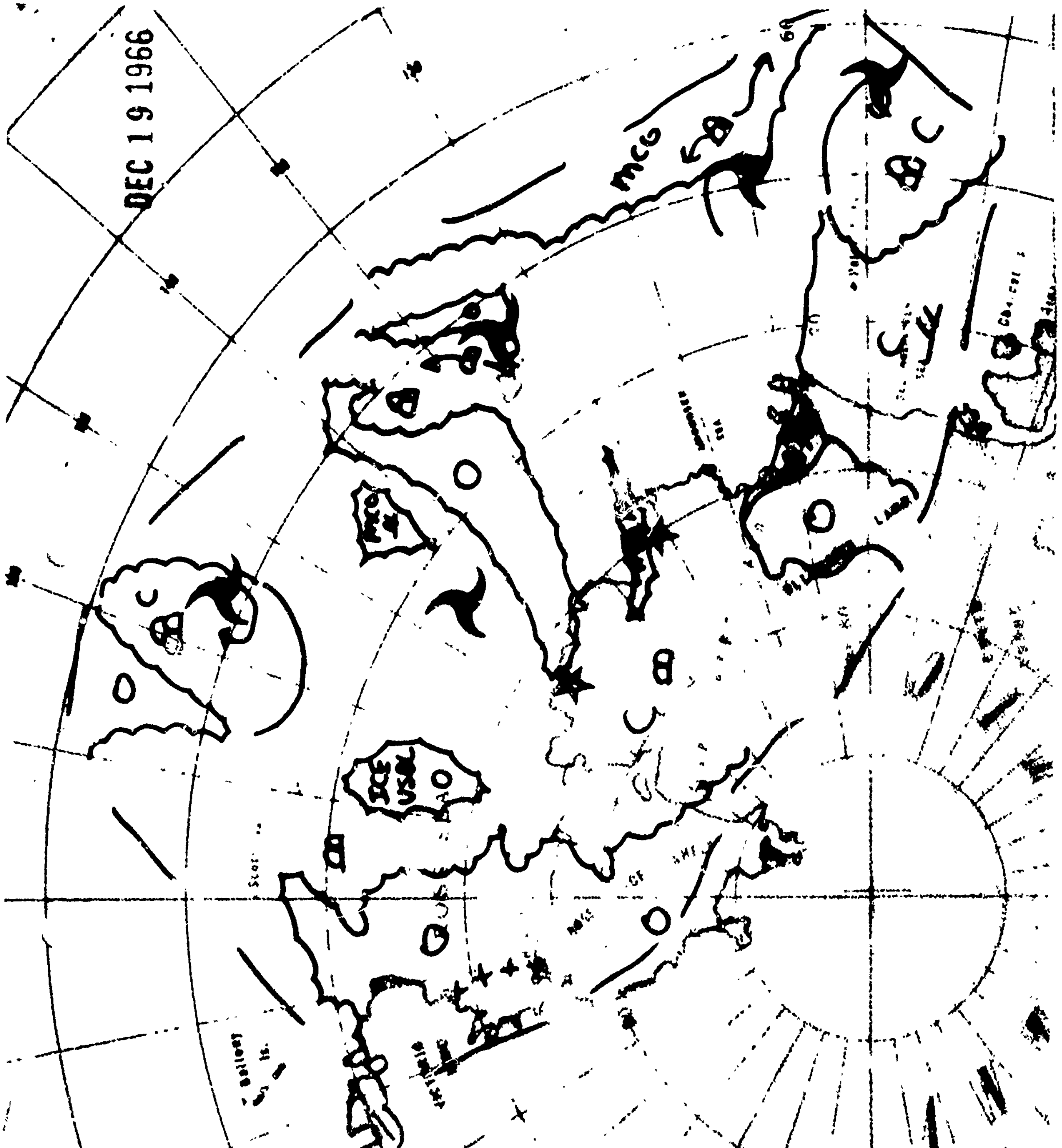
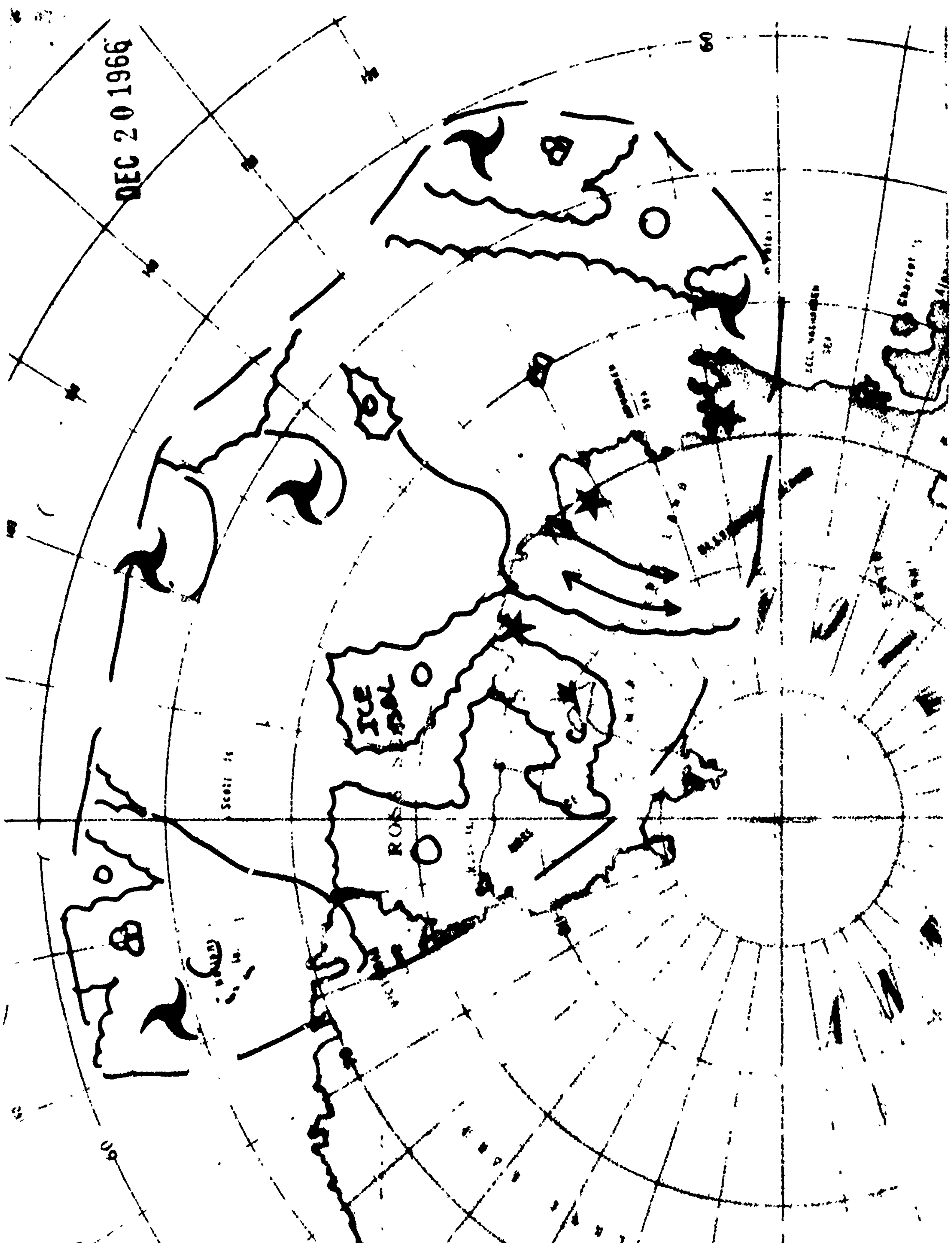
ROSS SEA
Scott Is
Peter I Is
Balleny Is
AMUNDSEN SEA


DEC 19 1966
MCG
ICE USGL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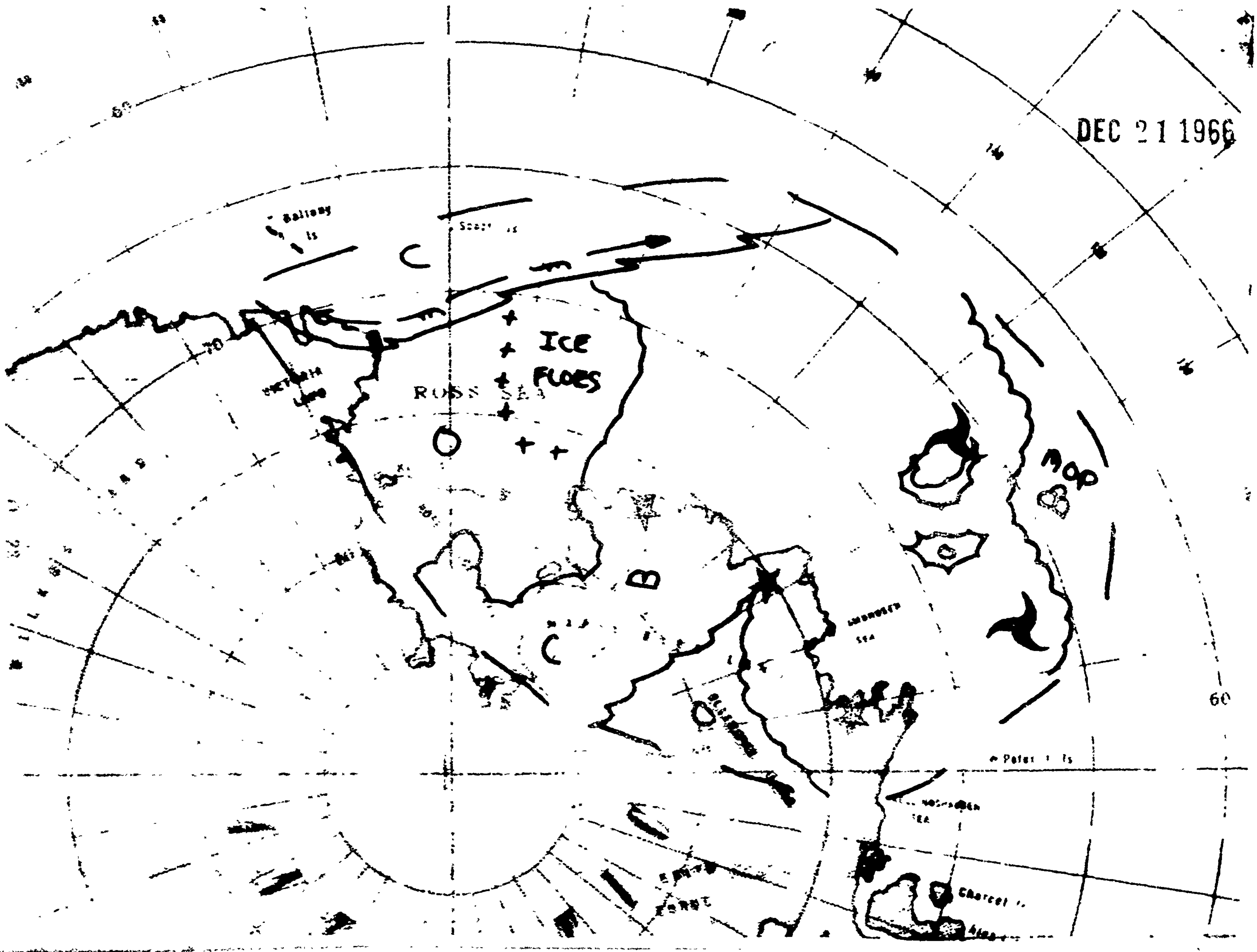
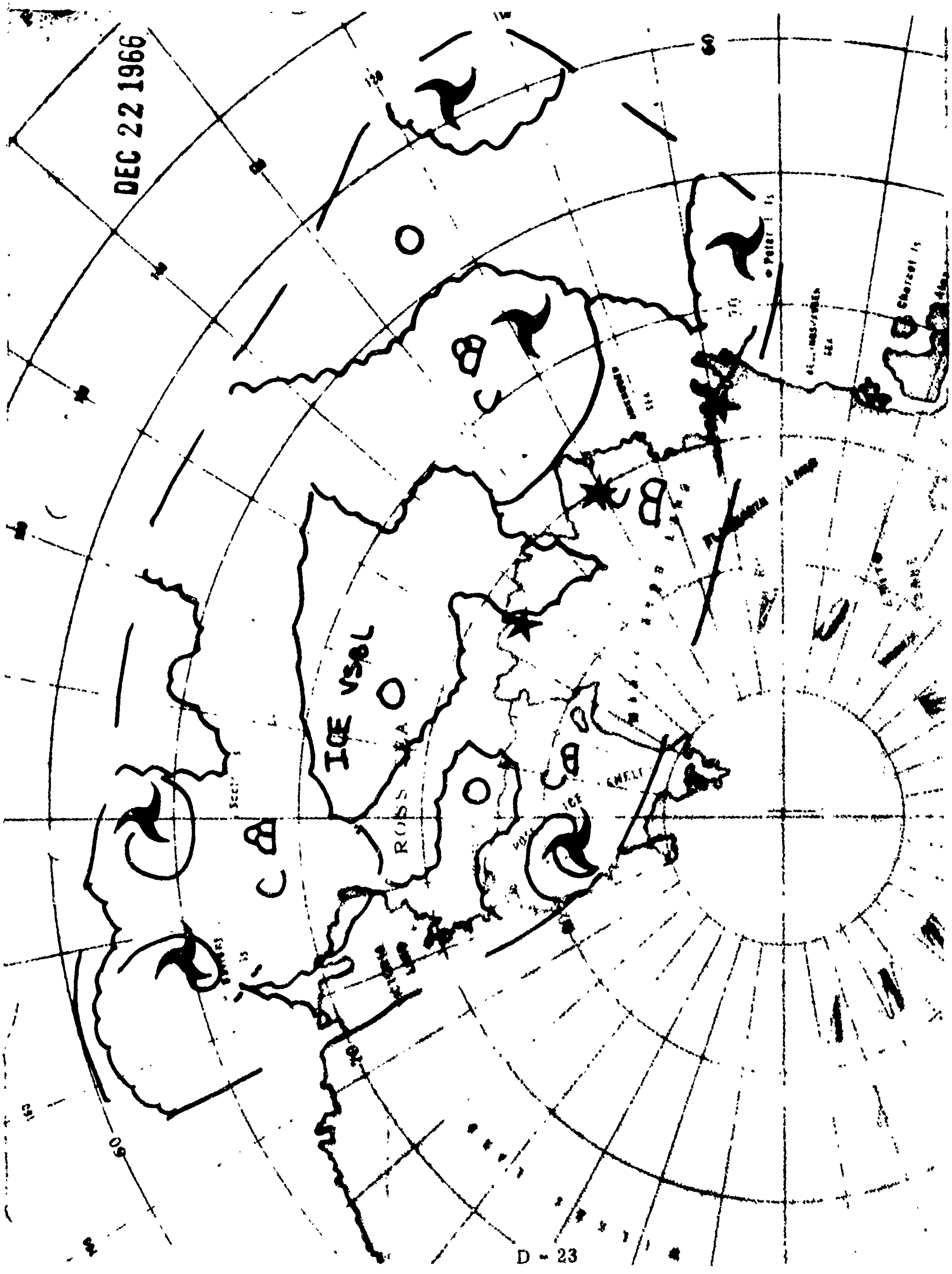
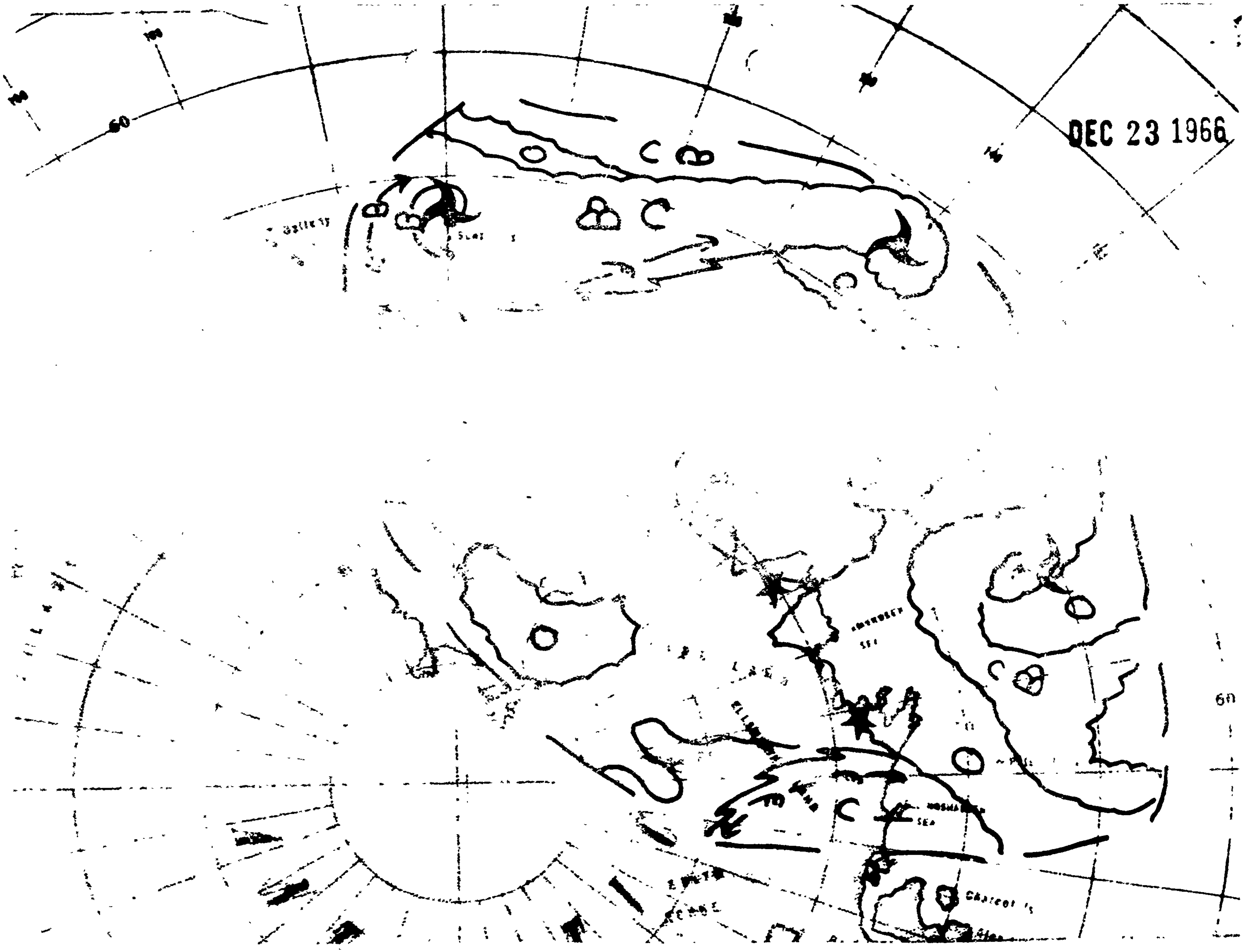
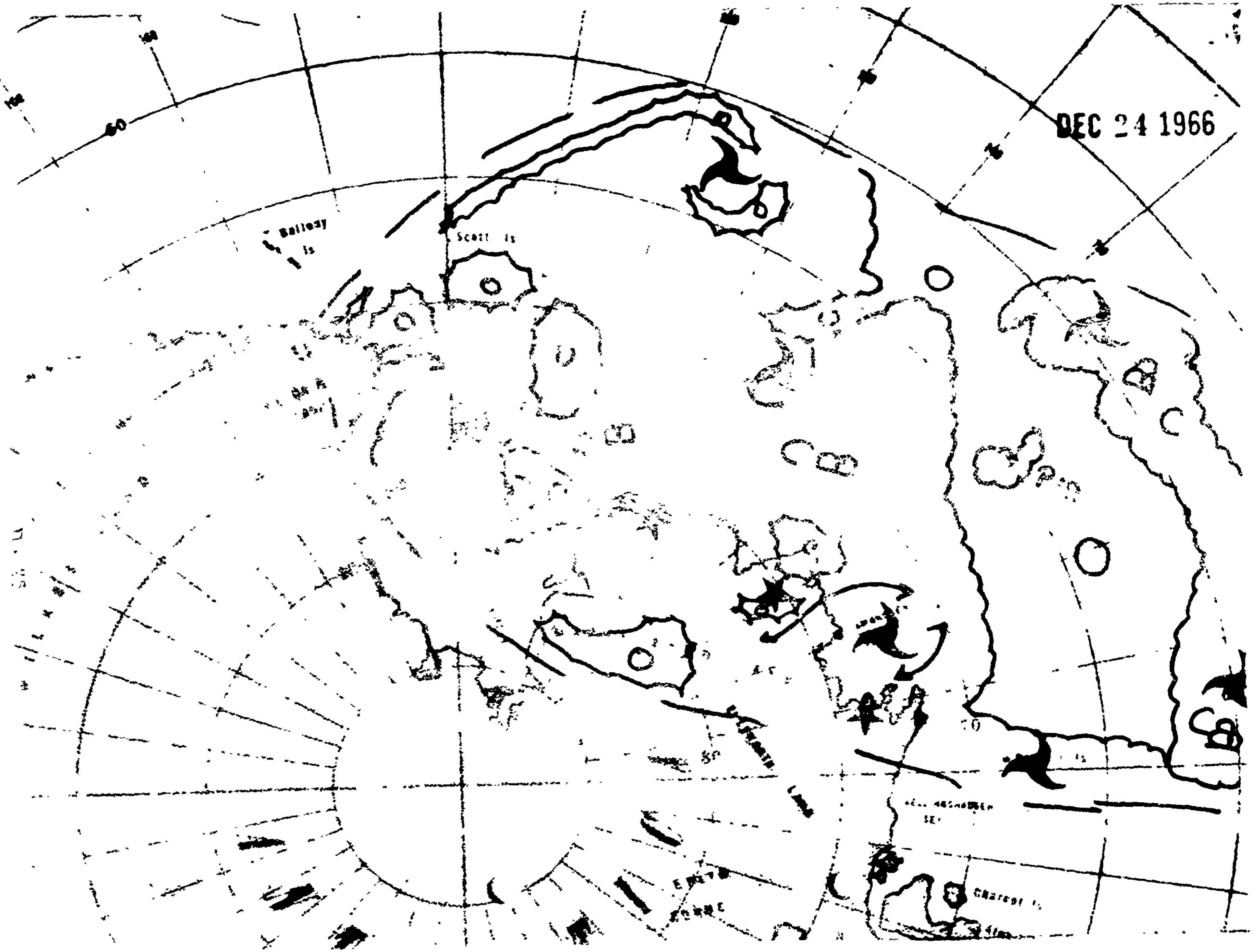
60
Scott Is
ROSS


DEC 21 1966
Balleny Is
Scott Is
ROSS SEA
ICE FLOES
Victoria Land
Peter I Is
Charcot I.
60
70


DEC 22 1966
ICE VSBL
ROSS


DEC 23 1966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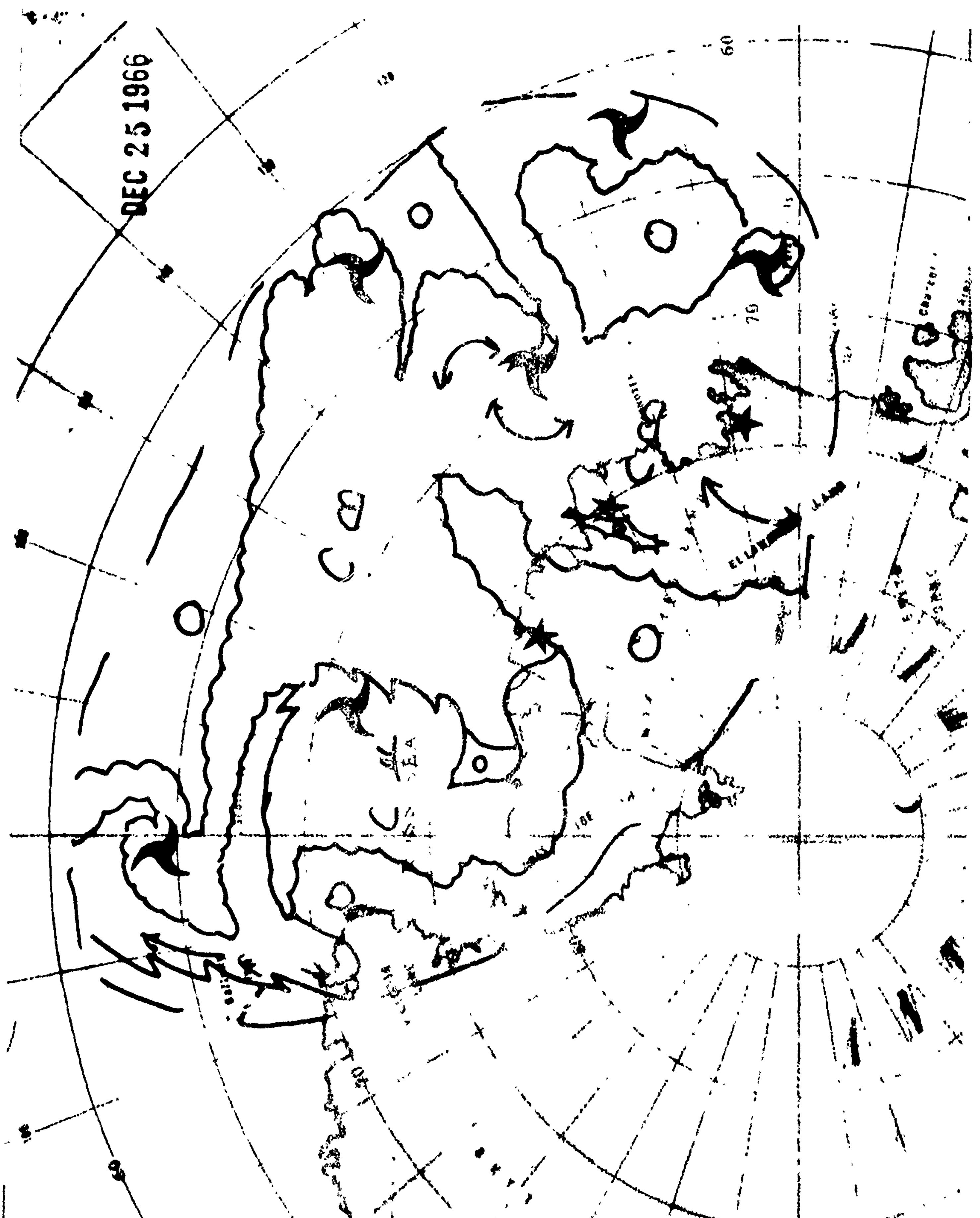
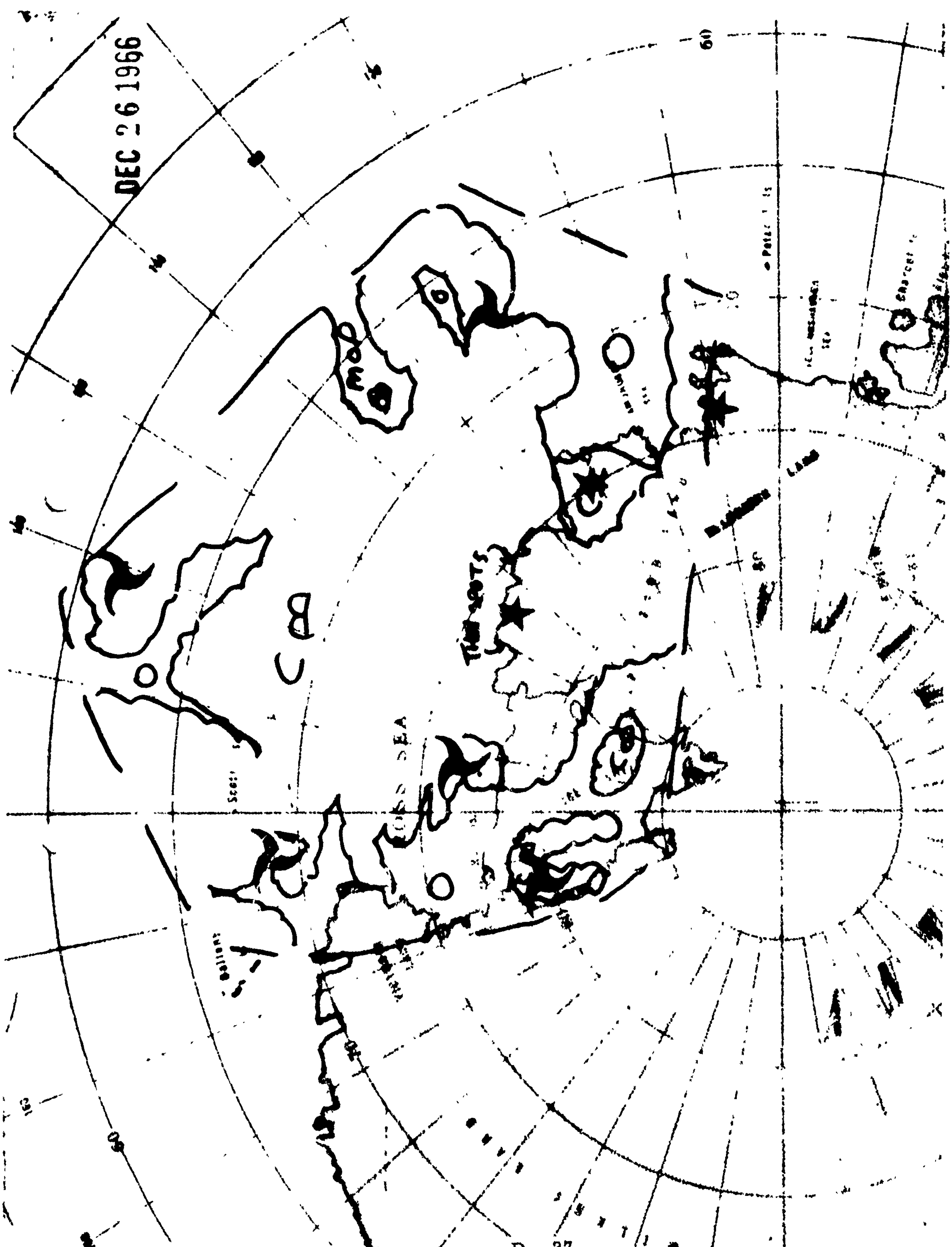
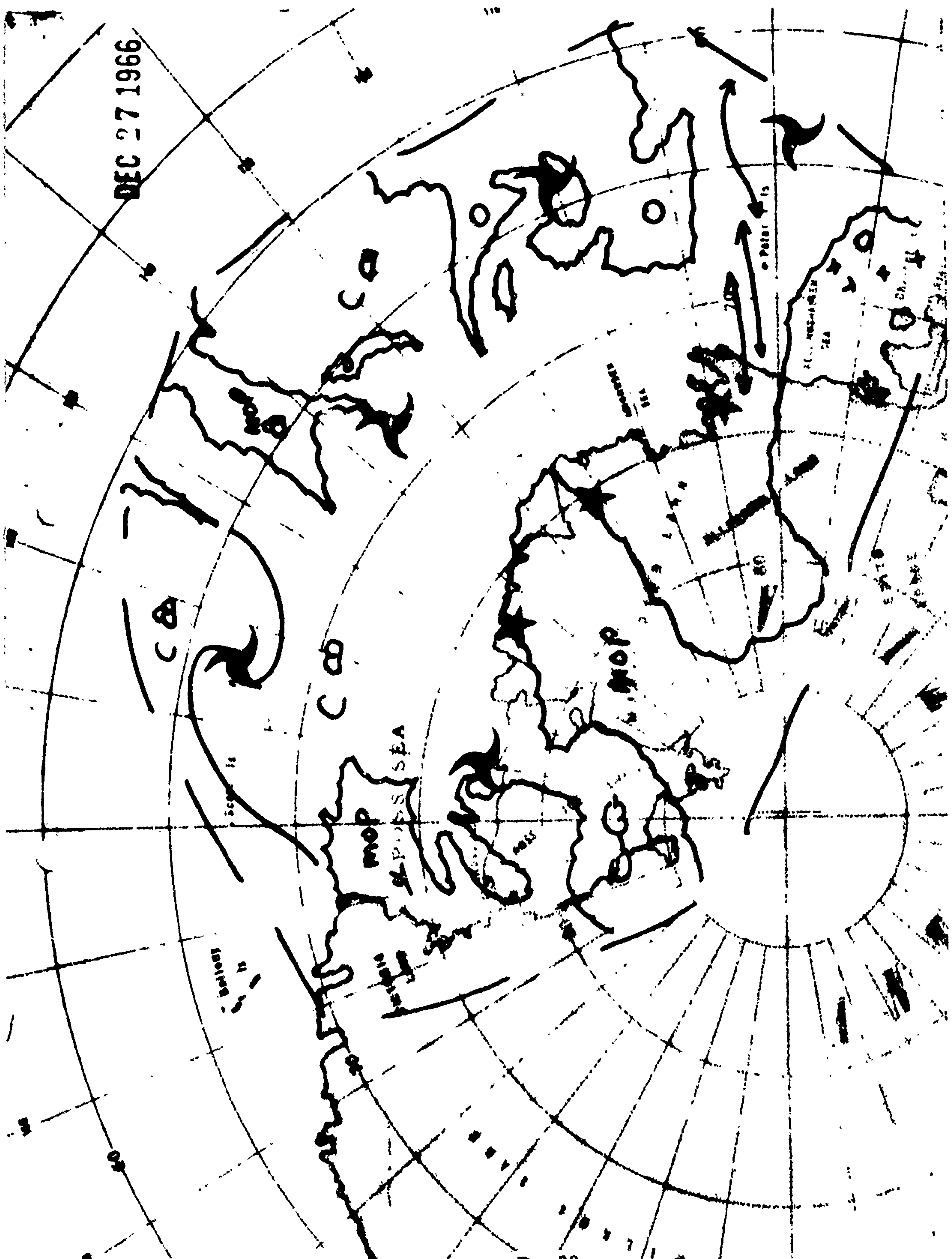
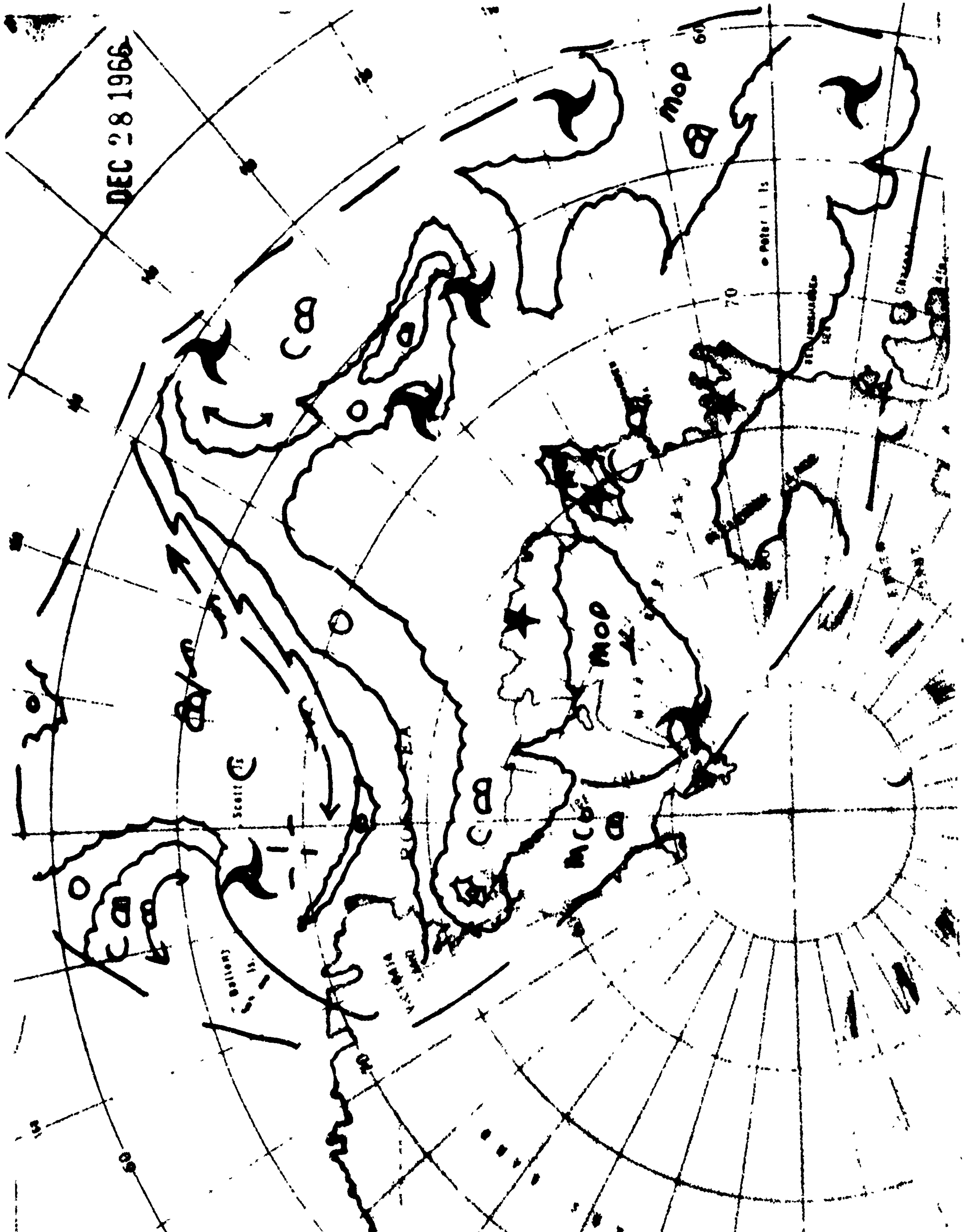
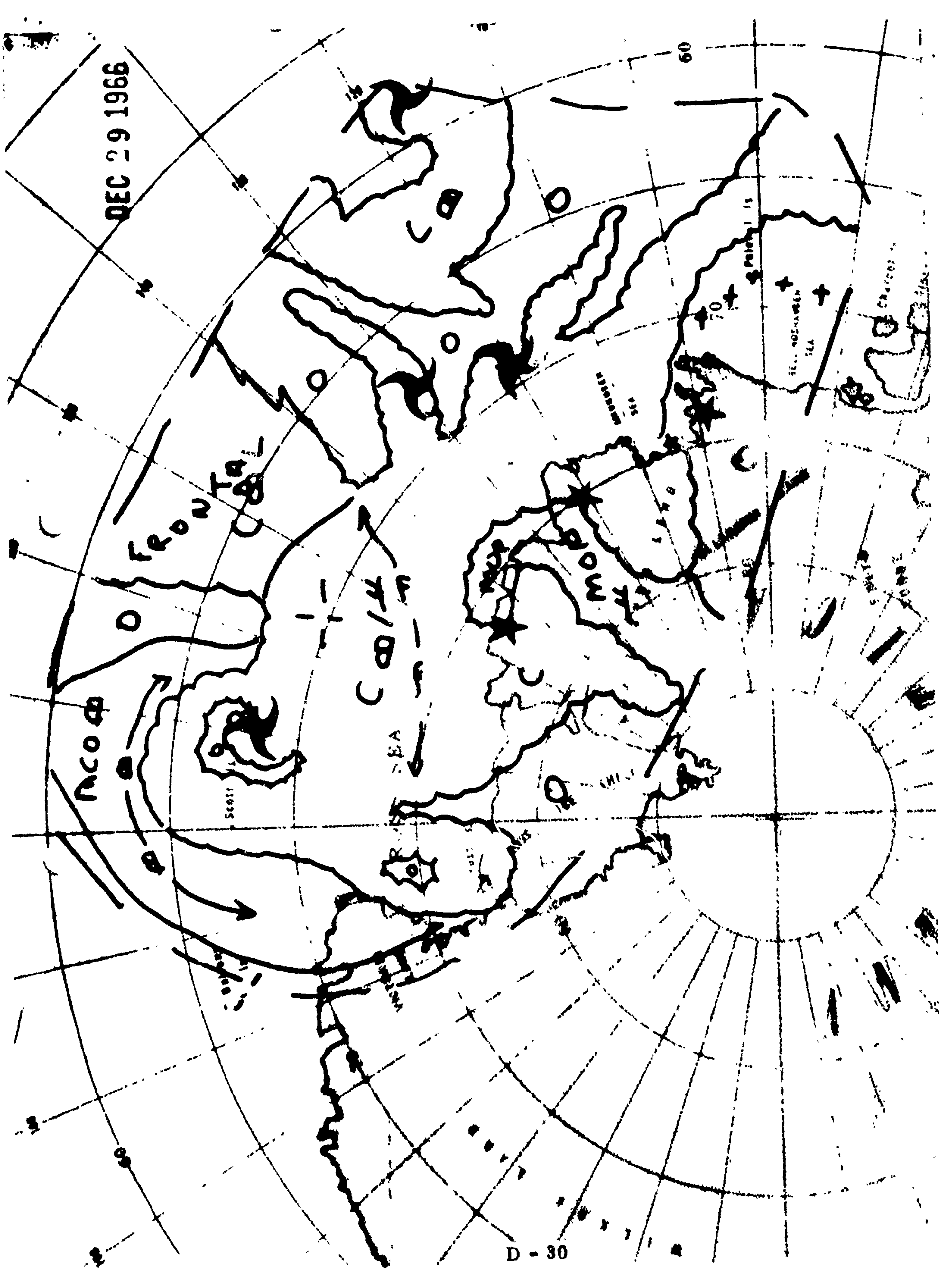
Balleny Is
Scott Is
Charcot I.

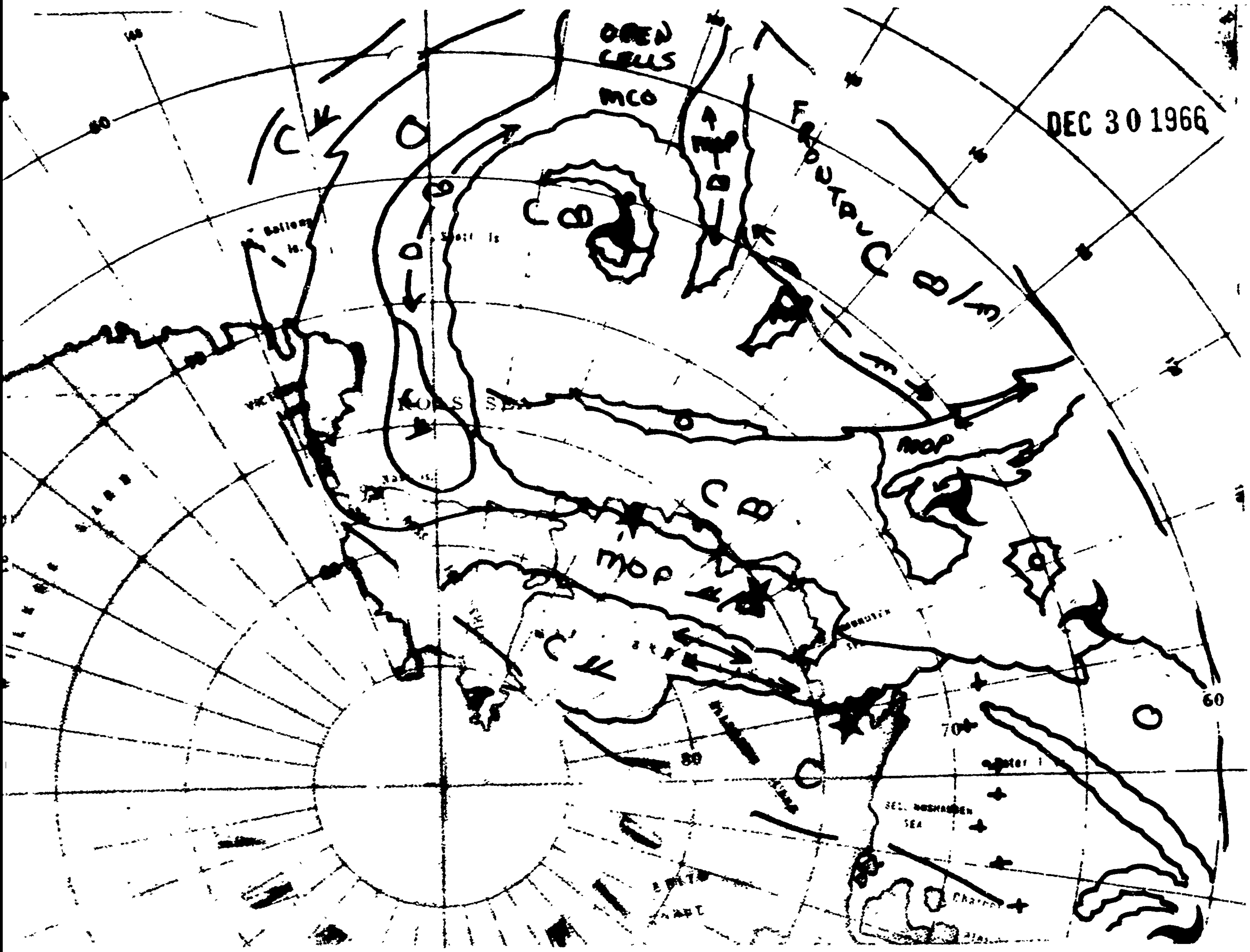

DEC 25 1966


DEC 26 1966
B
C

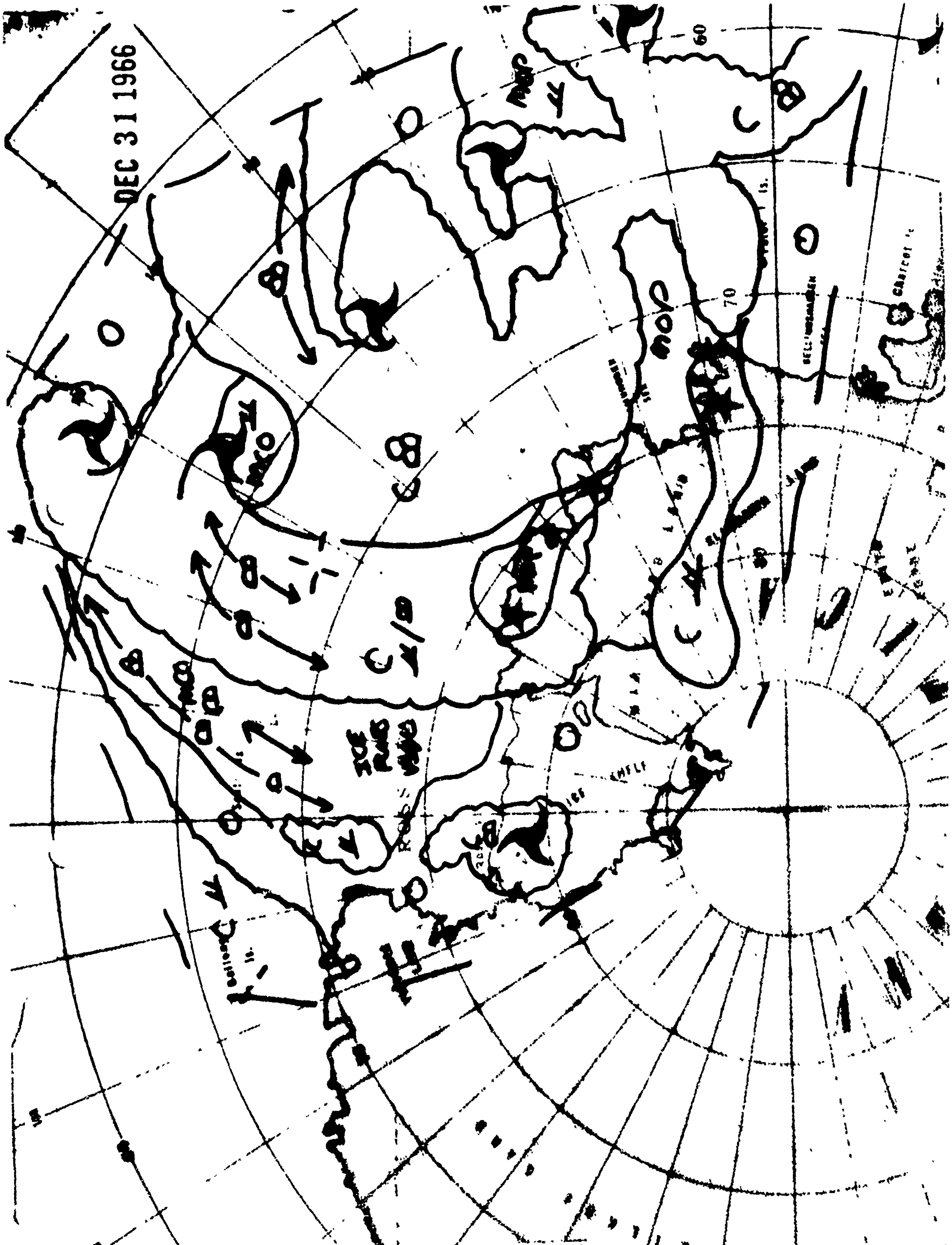

DEC 27 1966
MOP
MOP
MOP
SEA


DEC 28 1966
CB
MOP
MCOP
Scott
Peter I Is
VICTORIA LAND
Balleny Is.


DEC 29 1966
FRONTAL
60
70

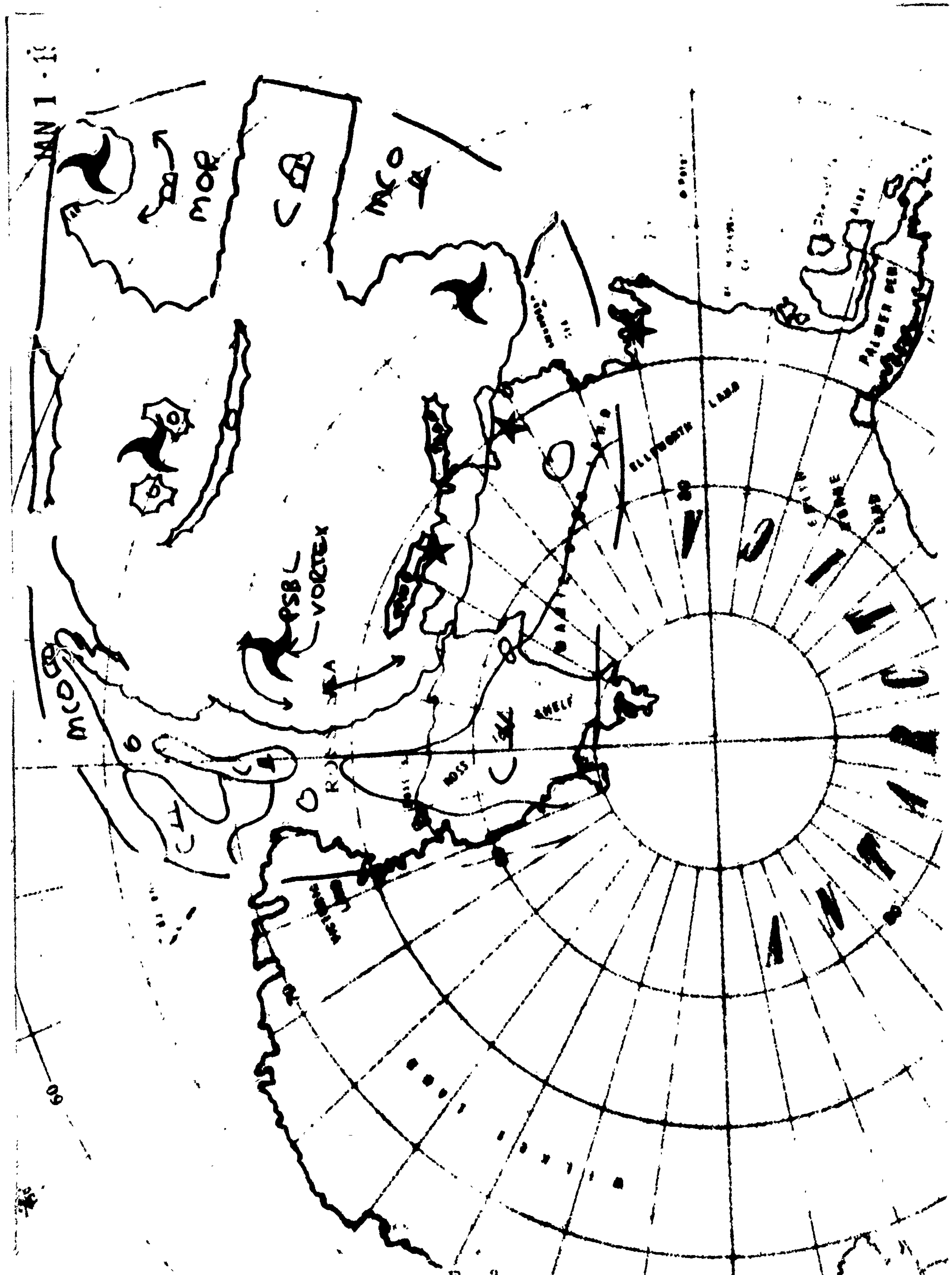


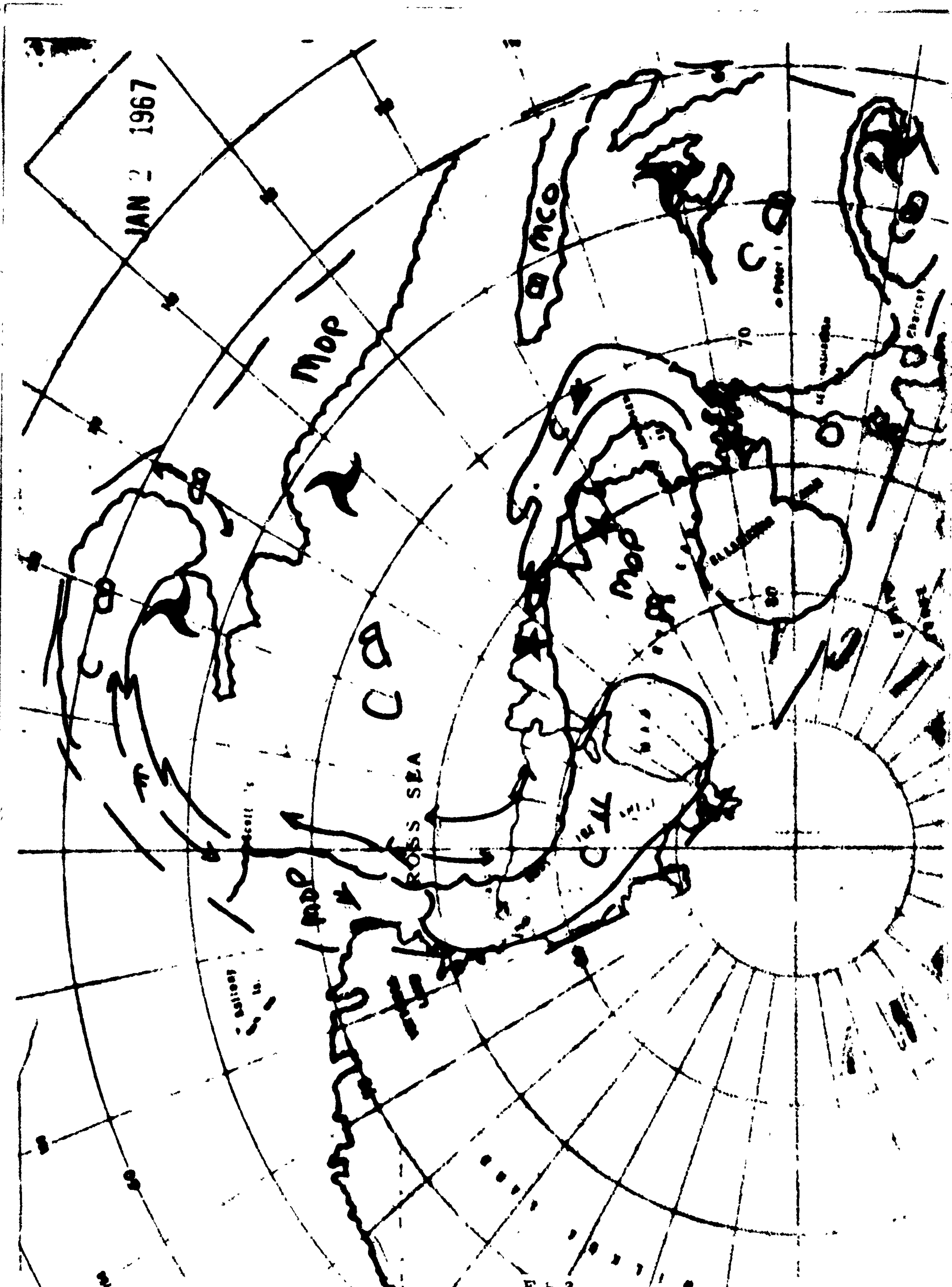
DEC 30 1966
OPEN CELLS
MCO
ROSS SEA
MOP
60
70
80


DEC 31 1966

APPENDIX E

JANUARY 1967 NEPHANALYSES


JAN 1 - 11
MOR
MCO
PSBL
VORTEX
ROSS
SHELF
ELLSWORTH LAND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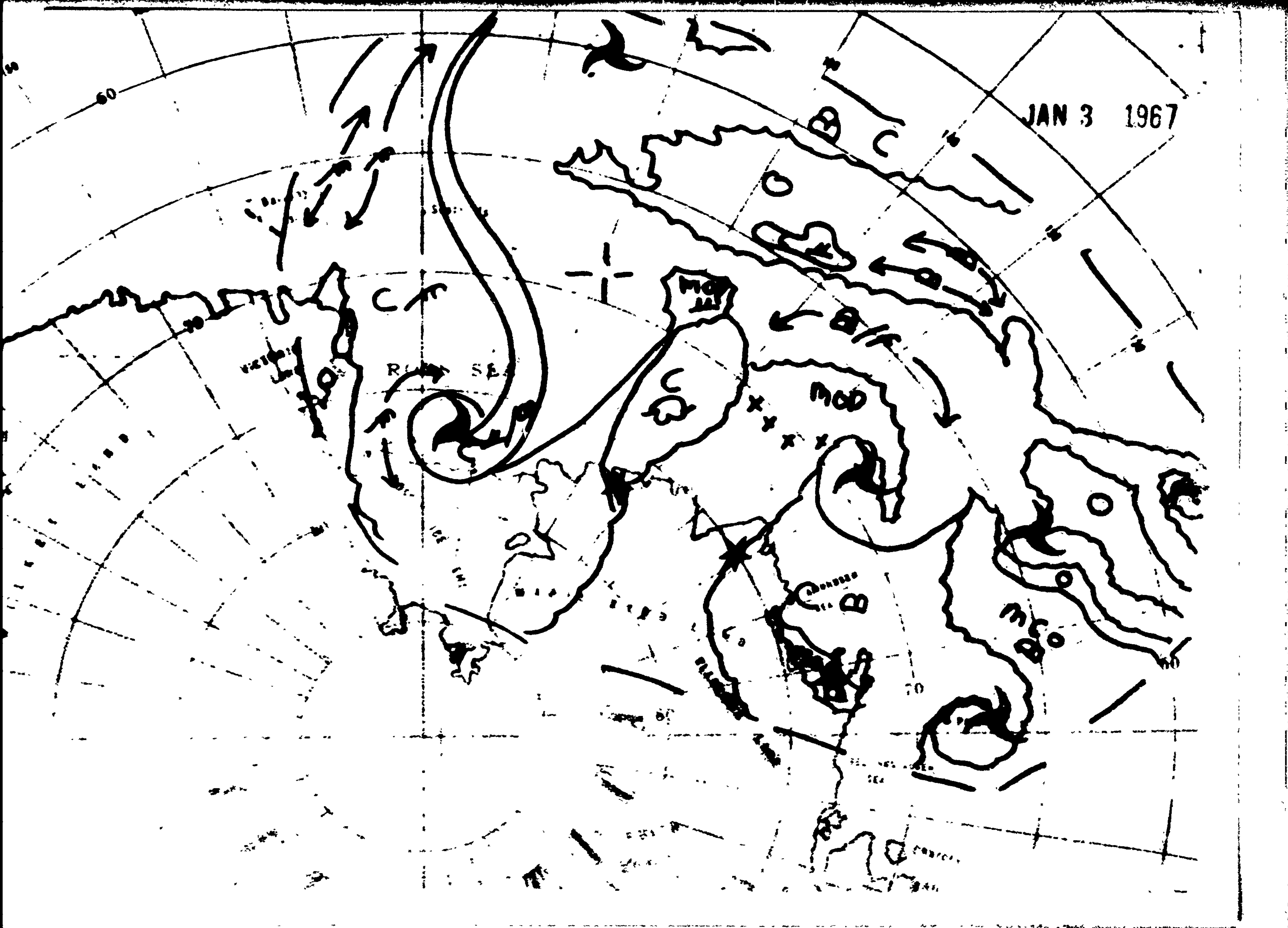
mOP
mCO
ROSS SEA
mOP


JAN 3 1967
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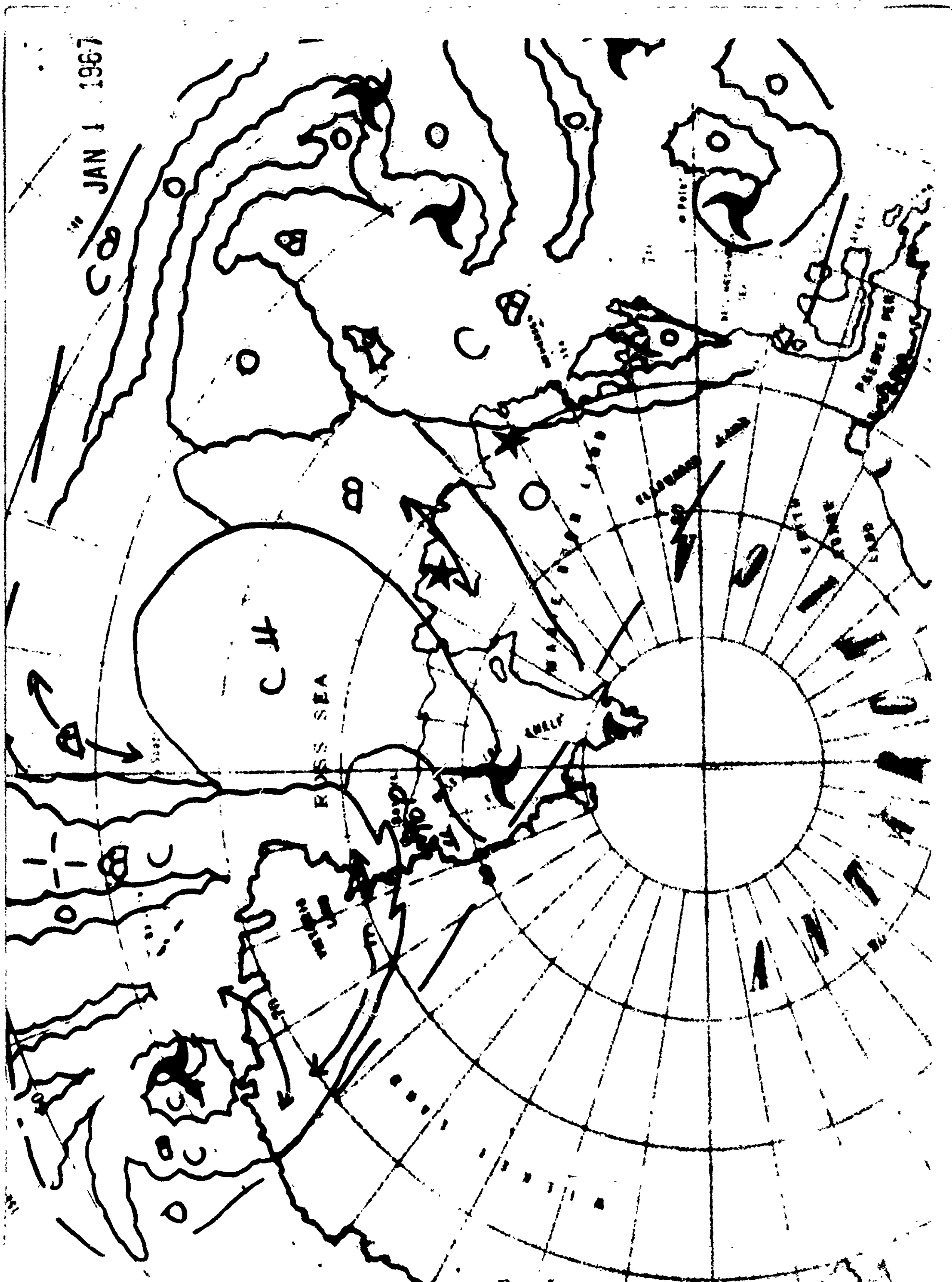
60
70
C
B
O
B/F
MOD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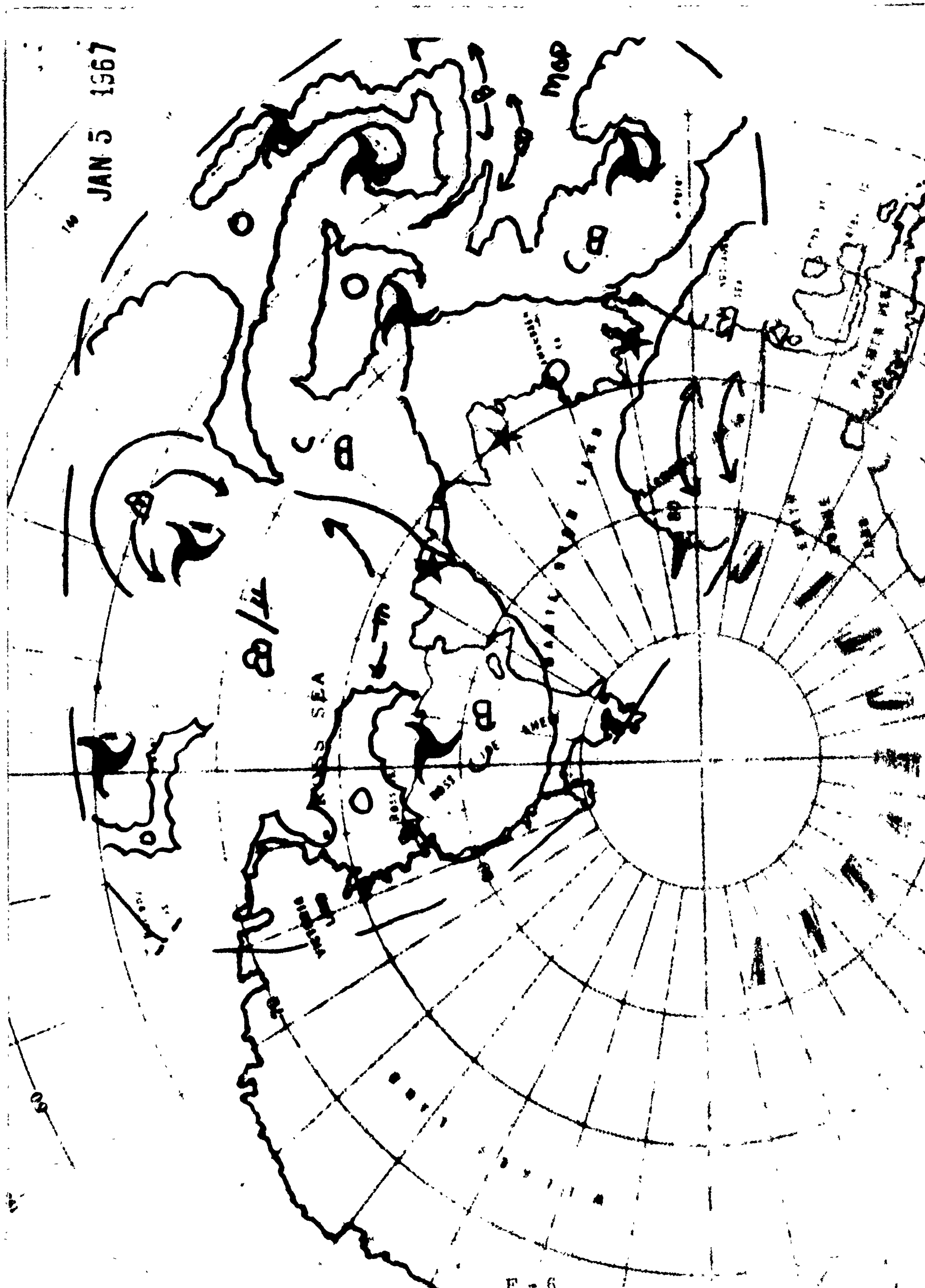
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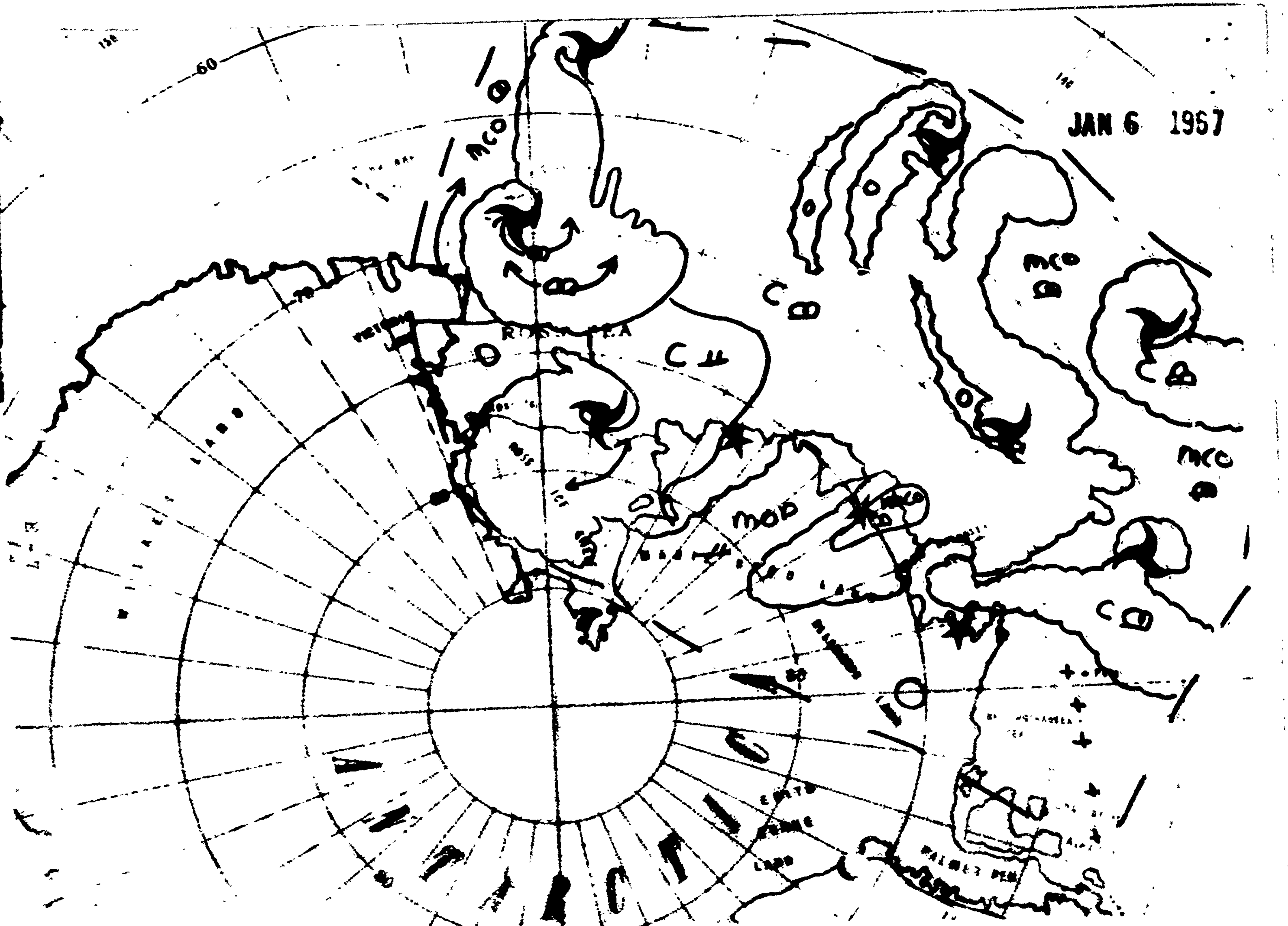
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MCO
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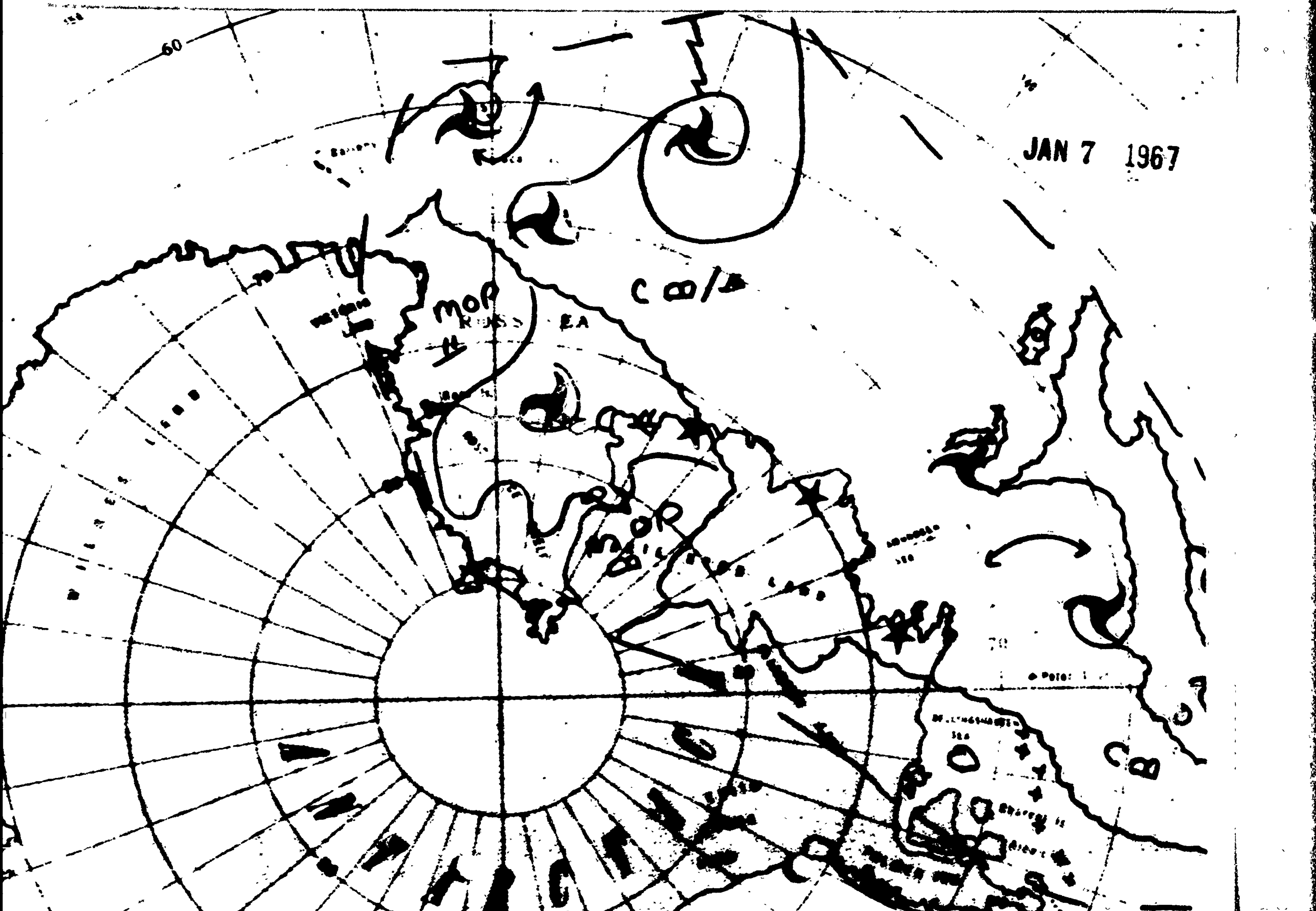
C
MOD
ANTARCTICA
PALMER PEN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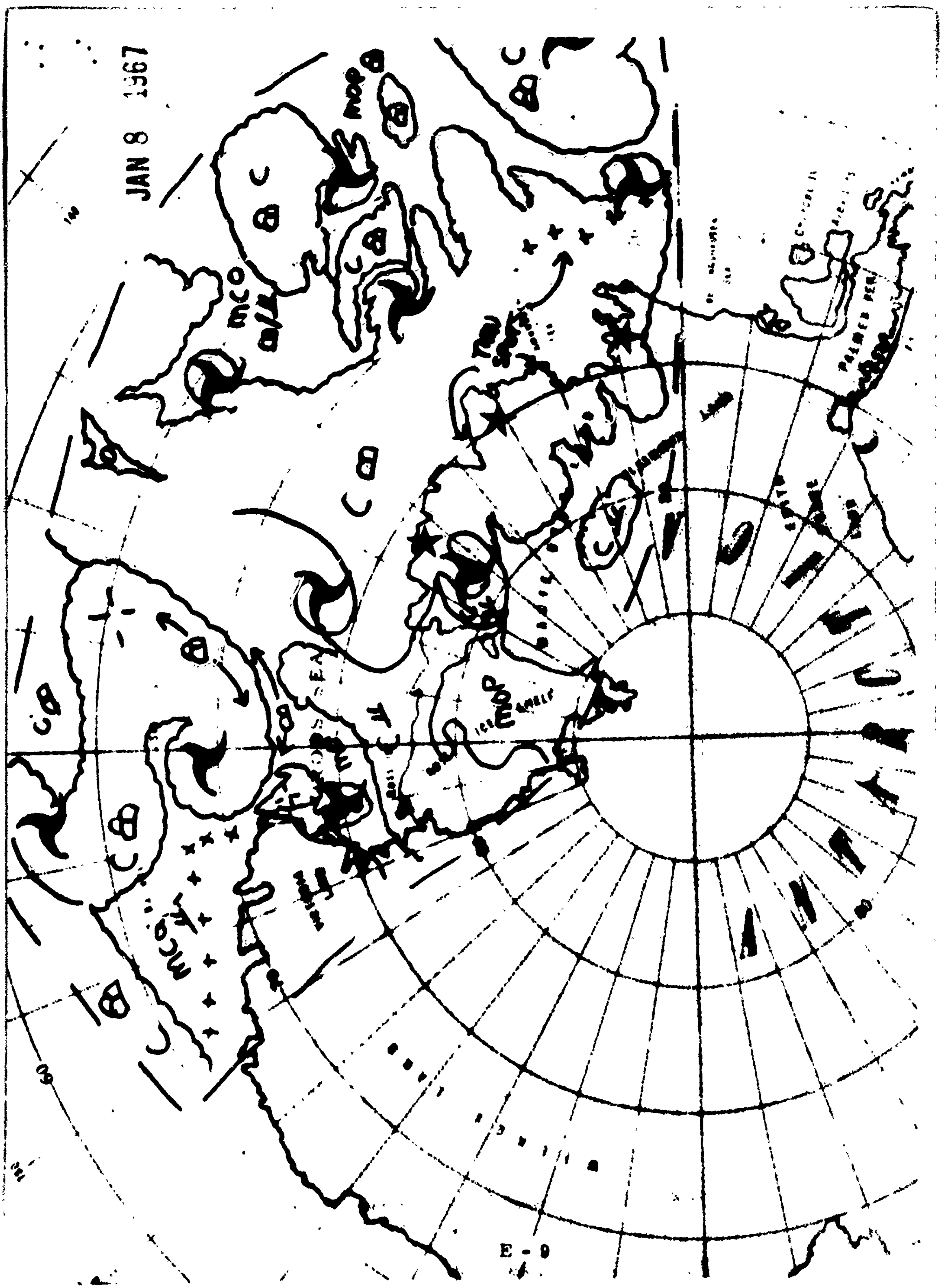
JAN 8 1967
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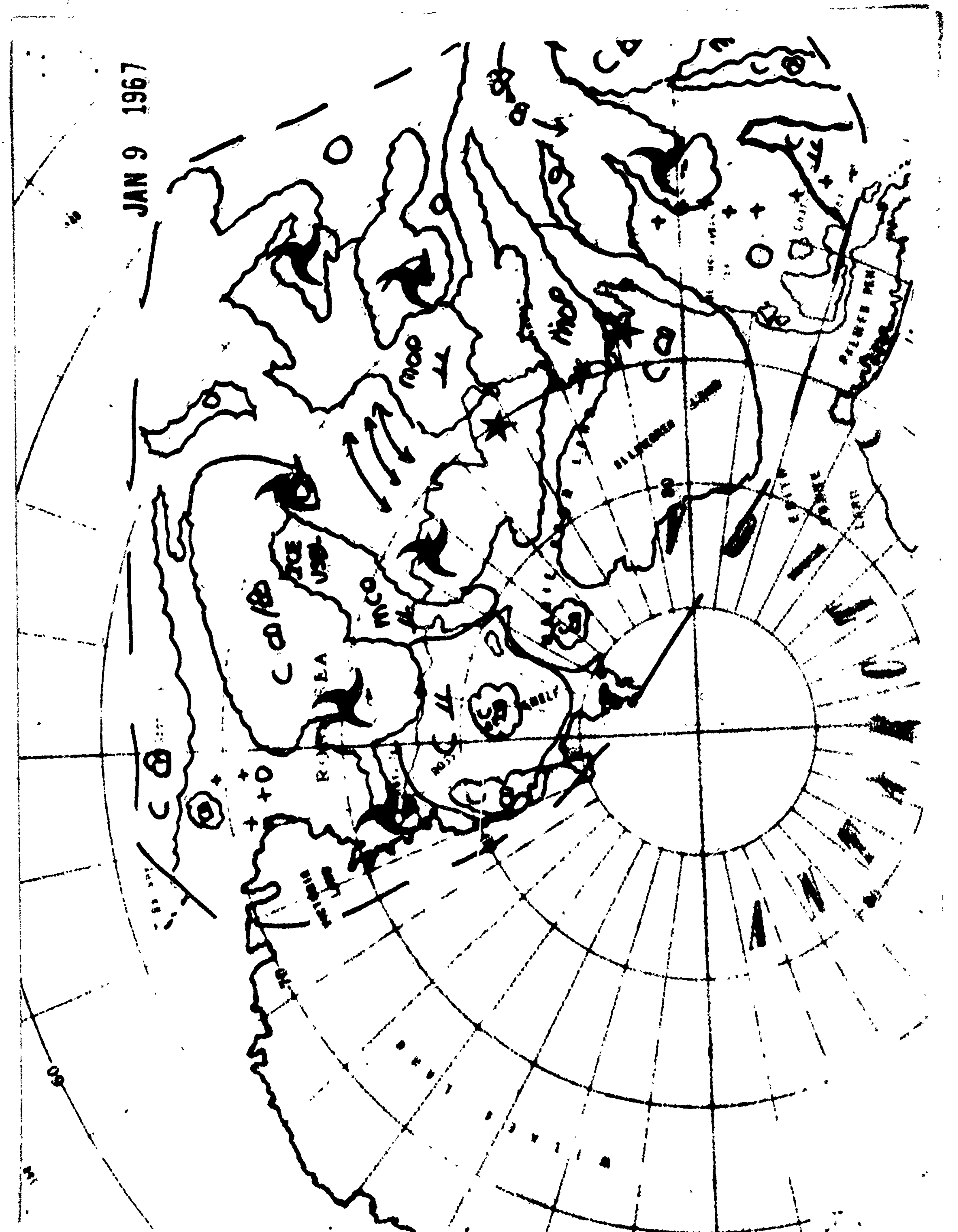
MDP
ICE SHELF
PALMER PEN.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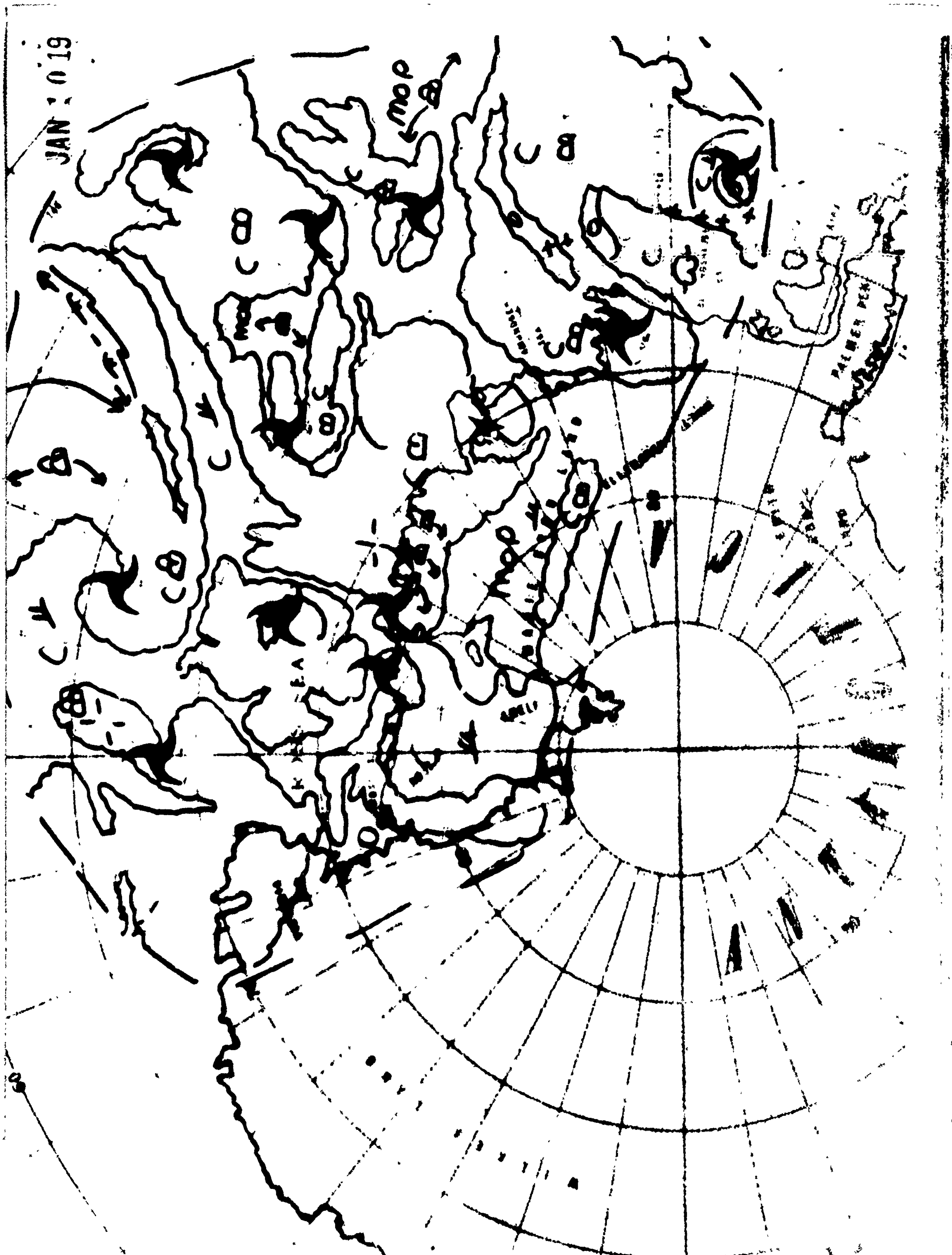

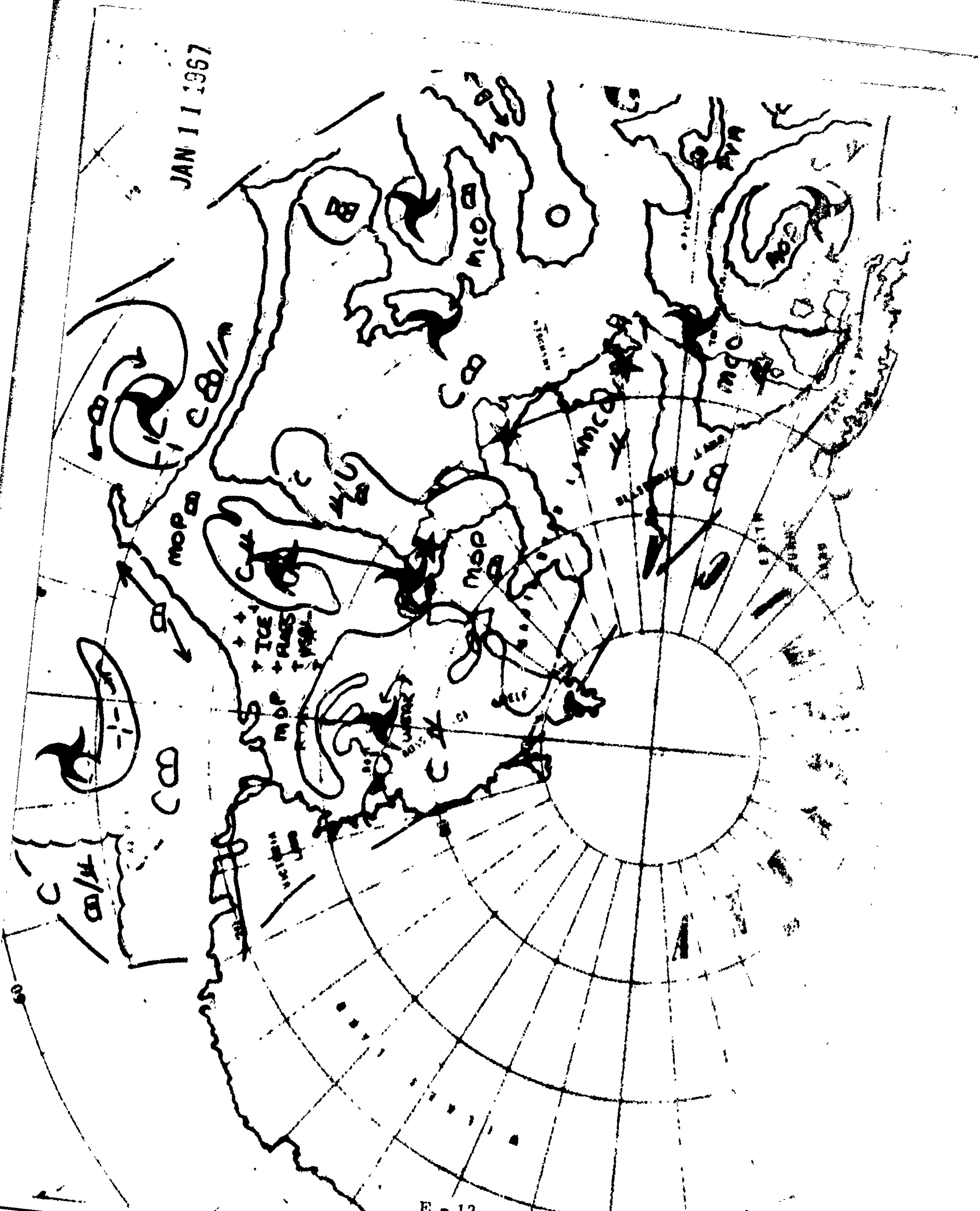
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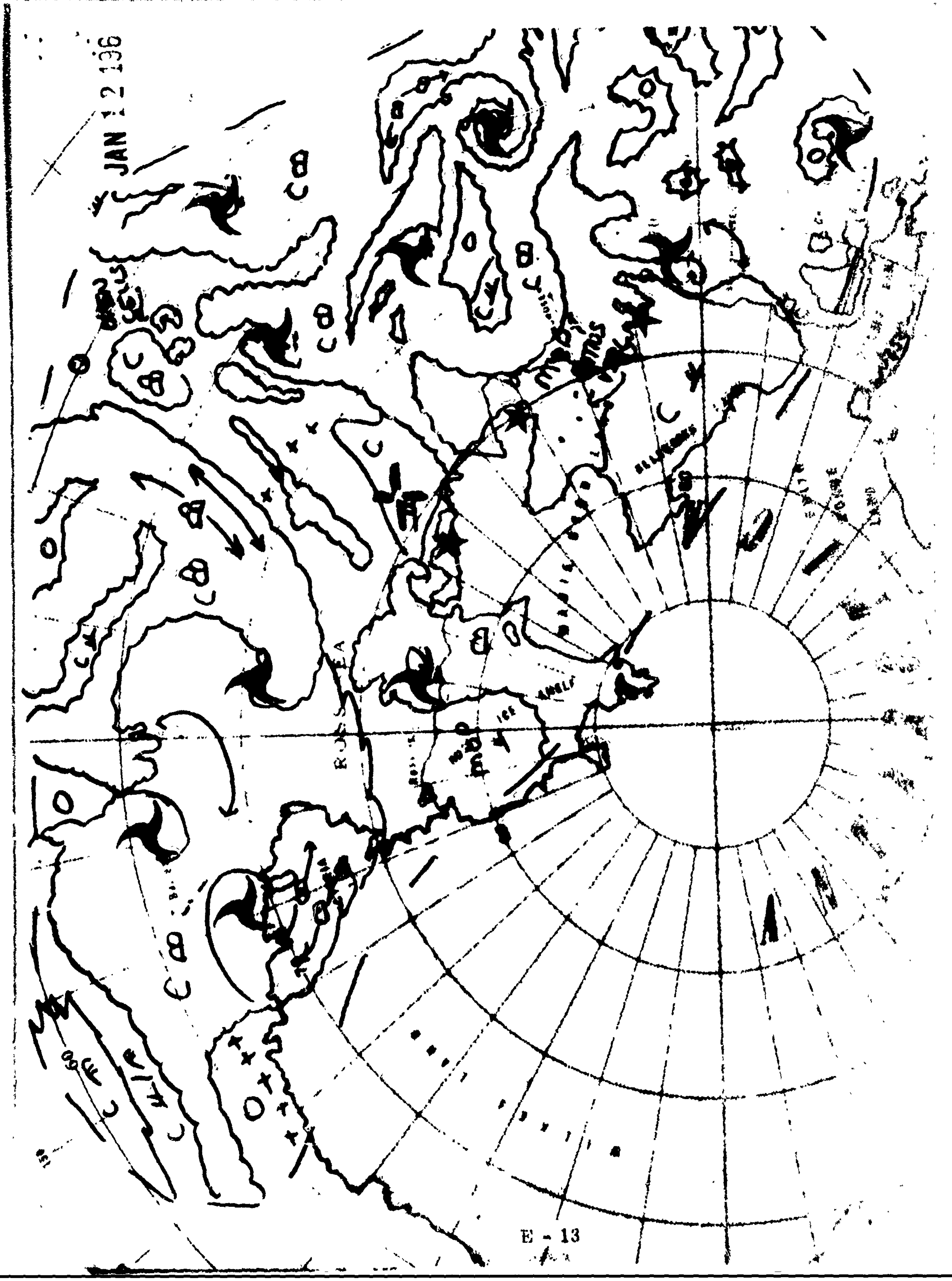


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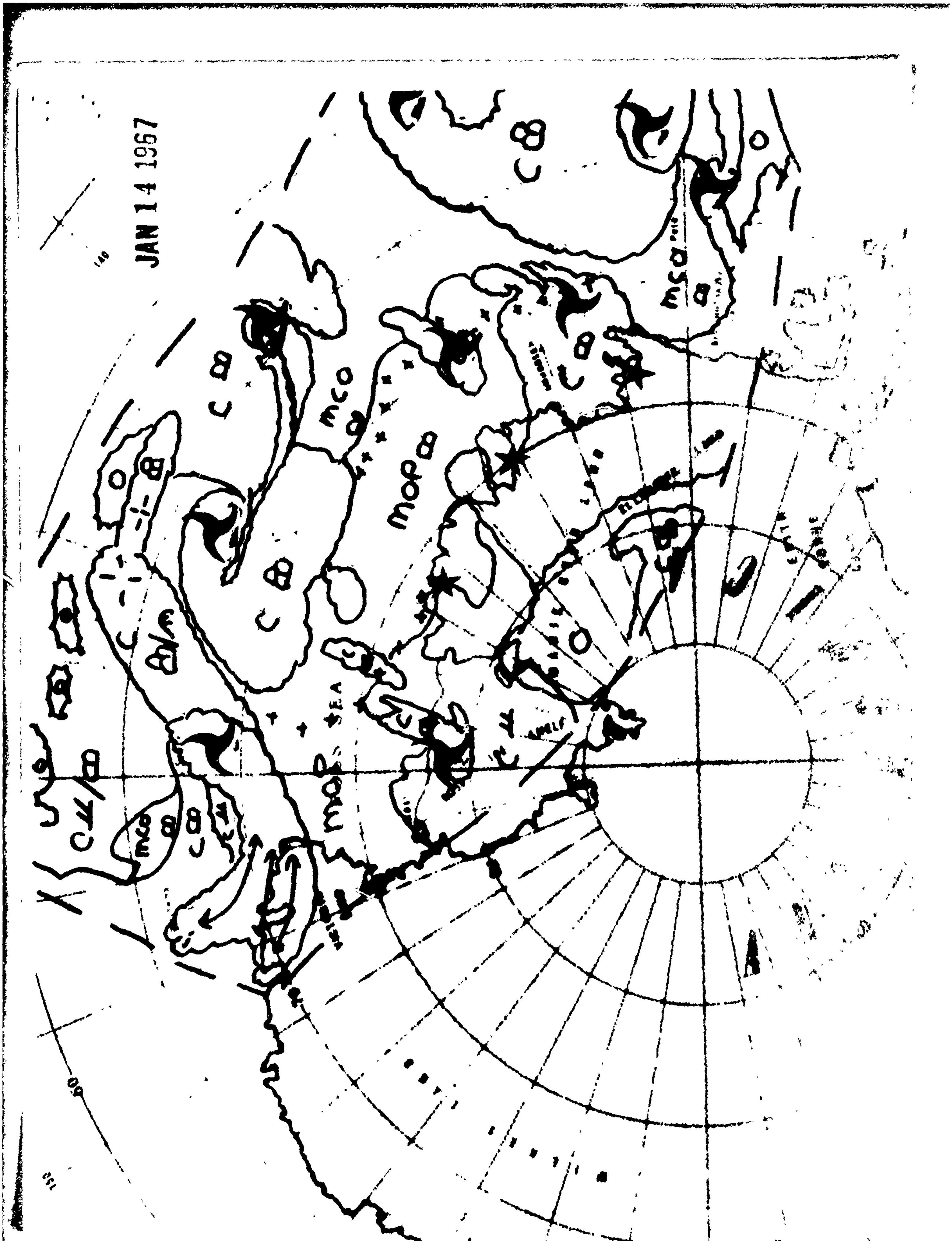
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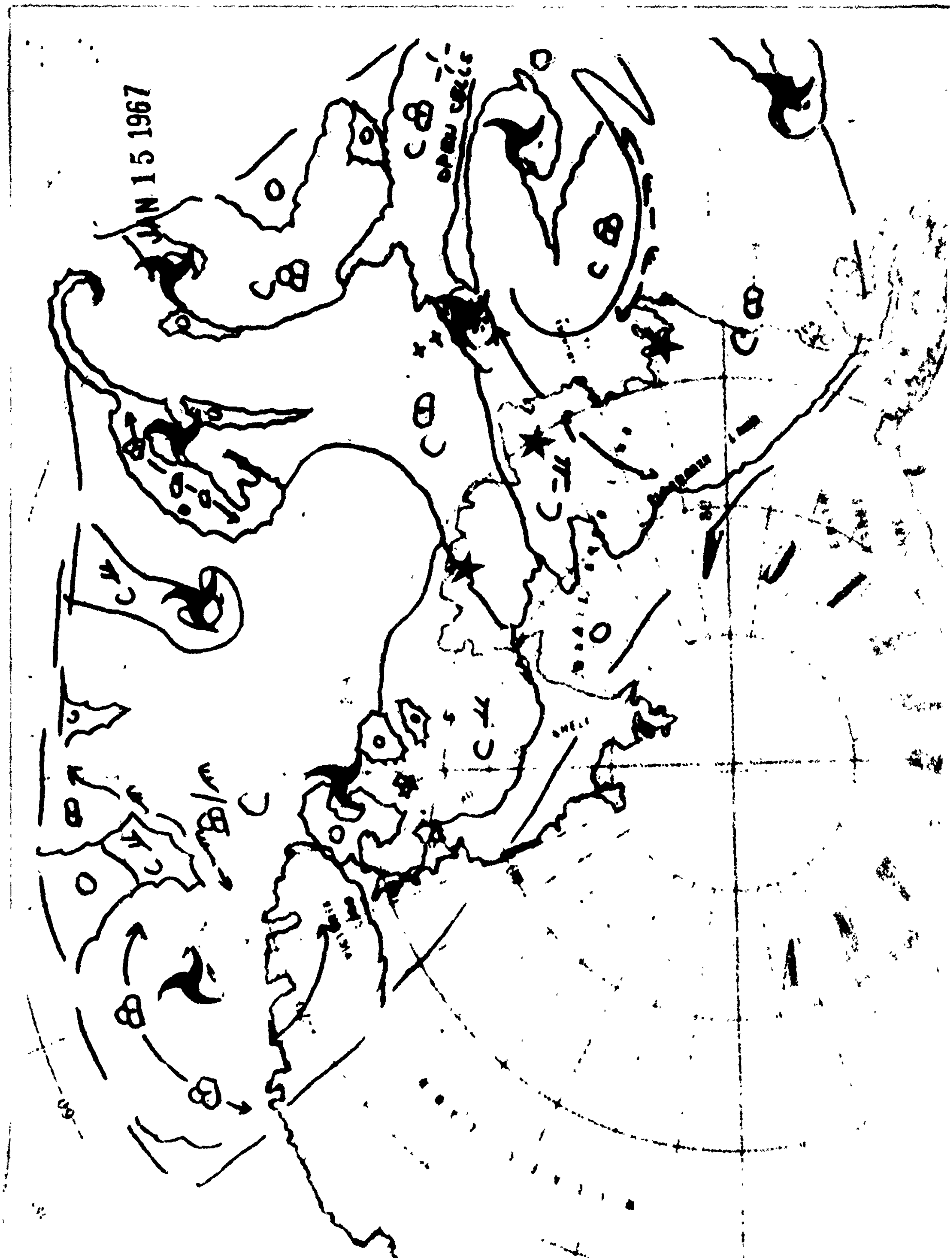
SEA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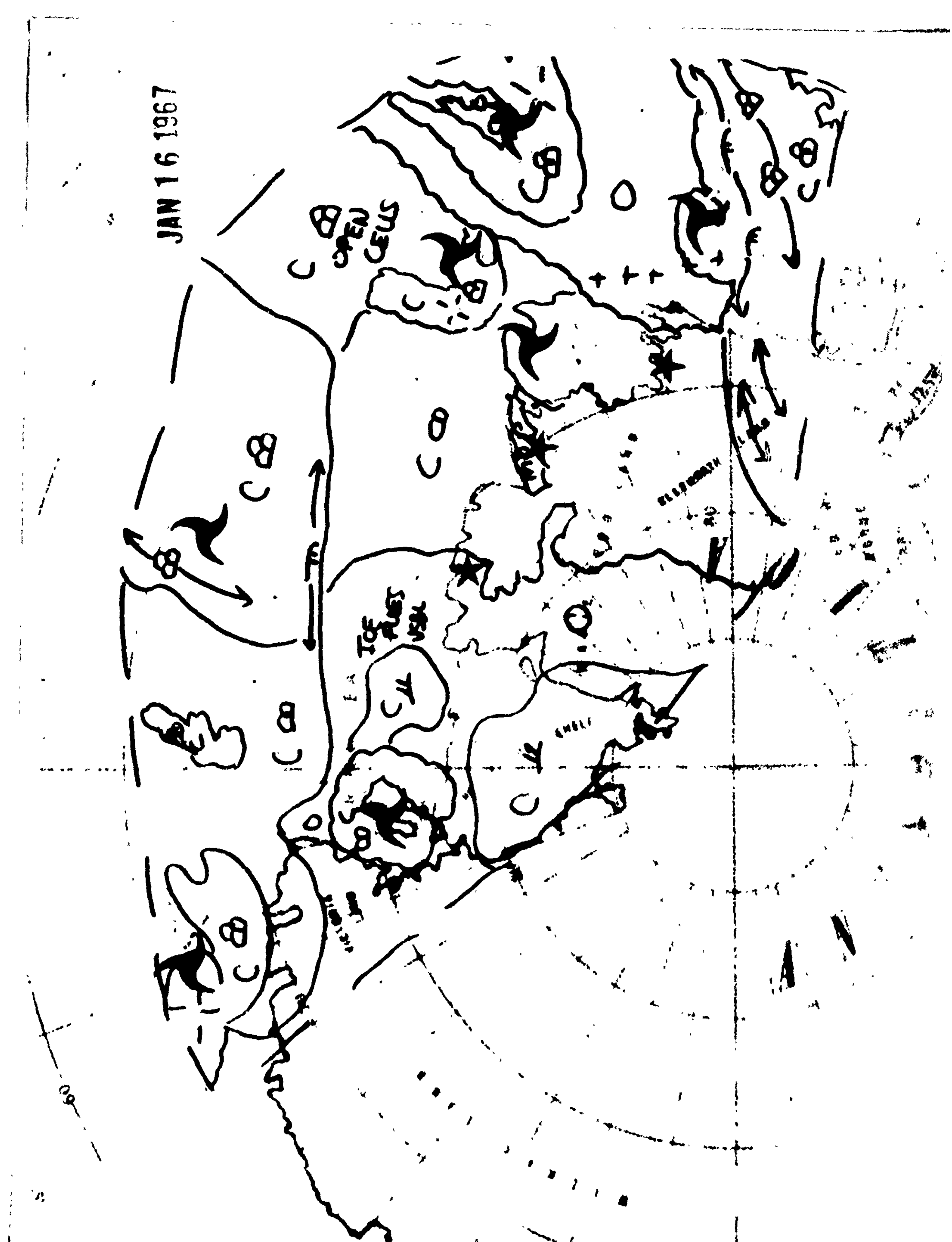
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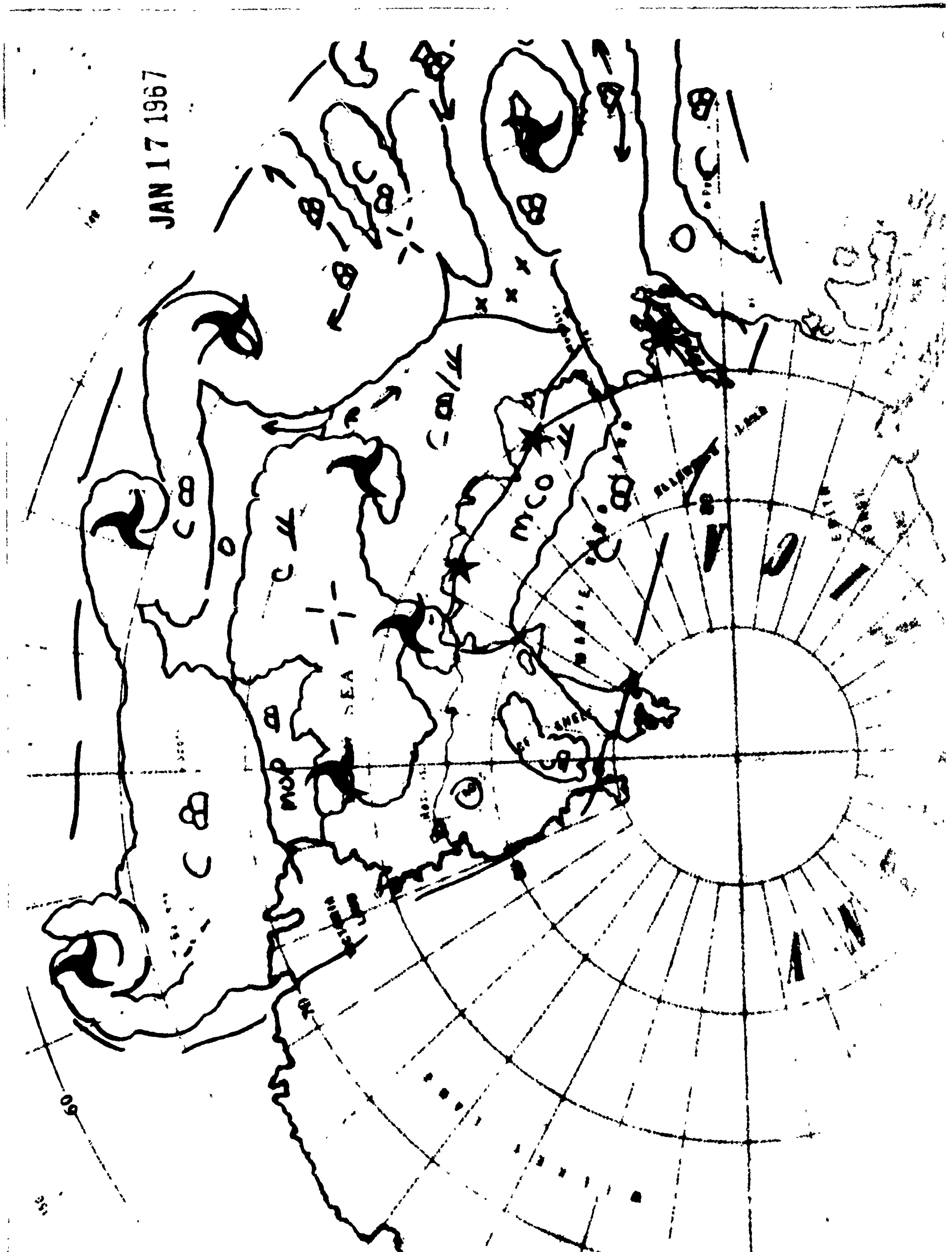
OPEN CELLS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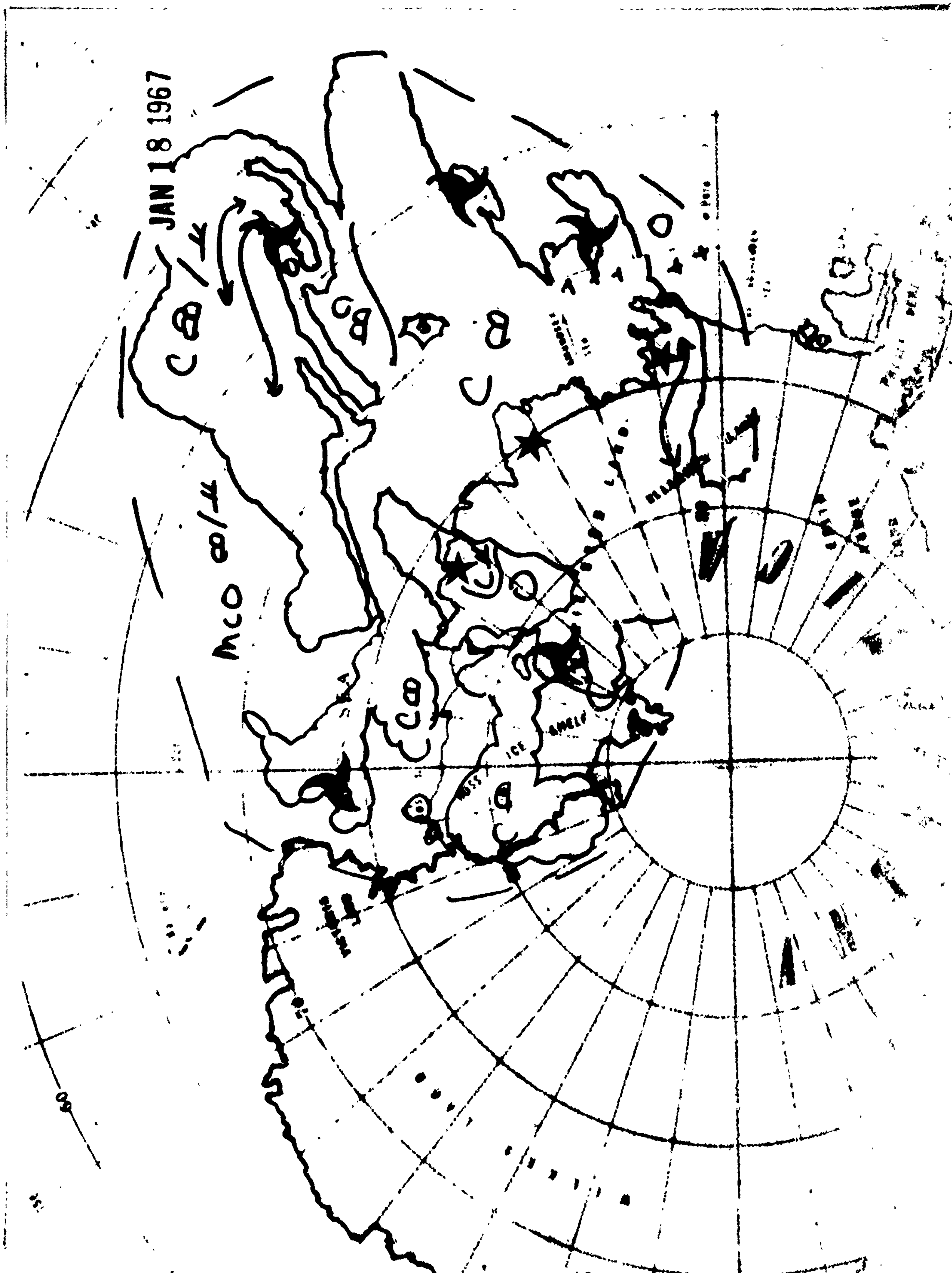
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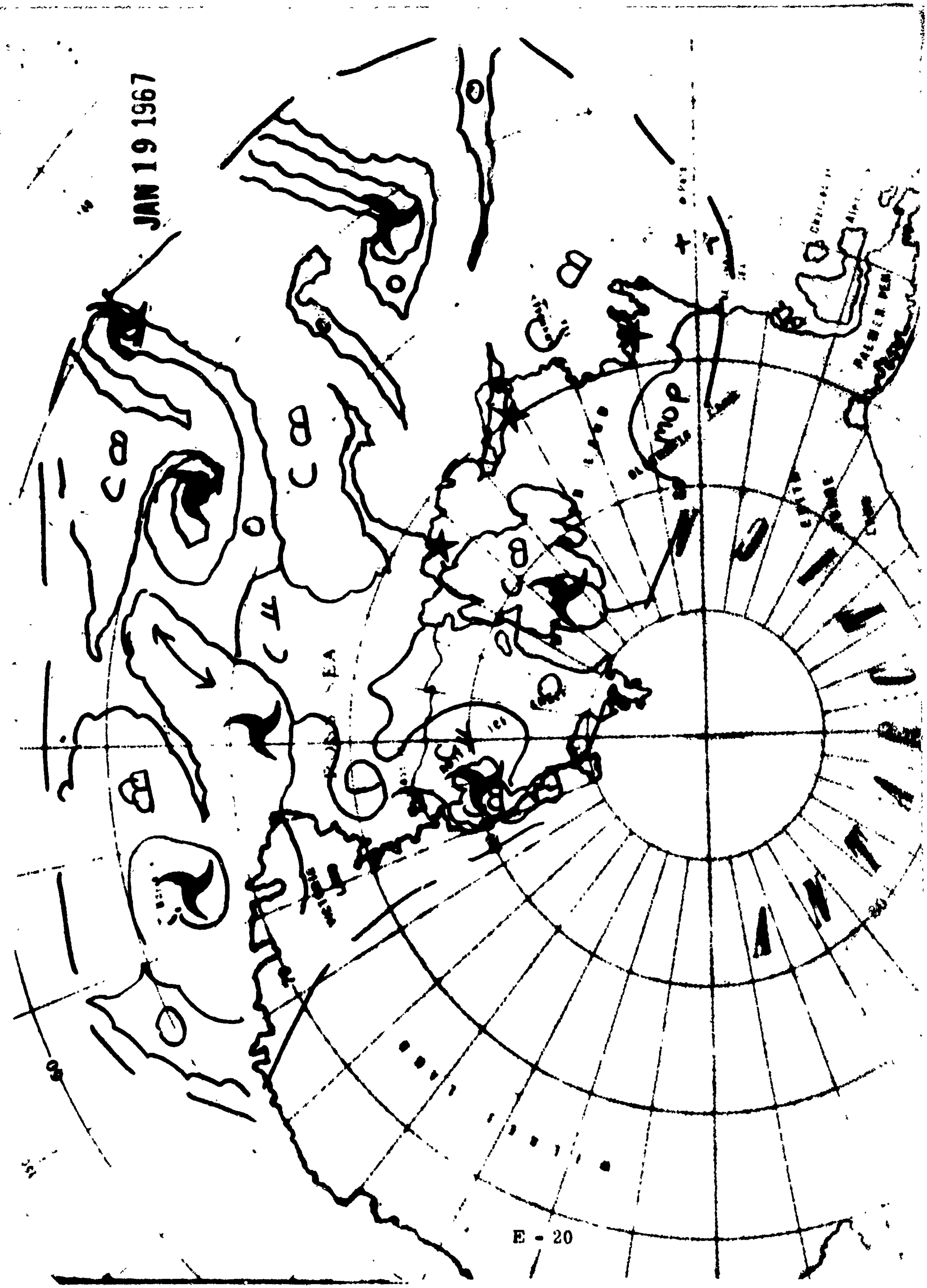
CB
B
MCO
ROSS
ICE
SHELF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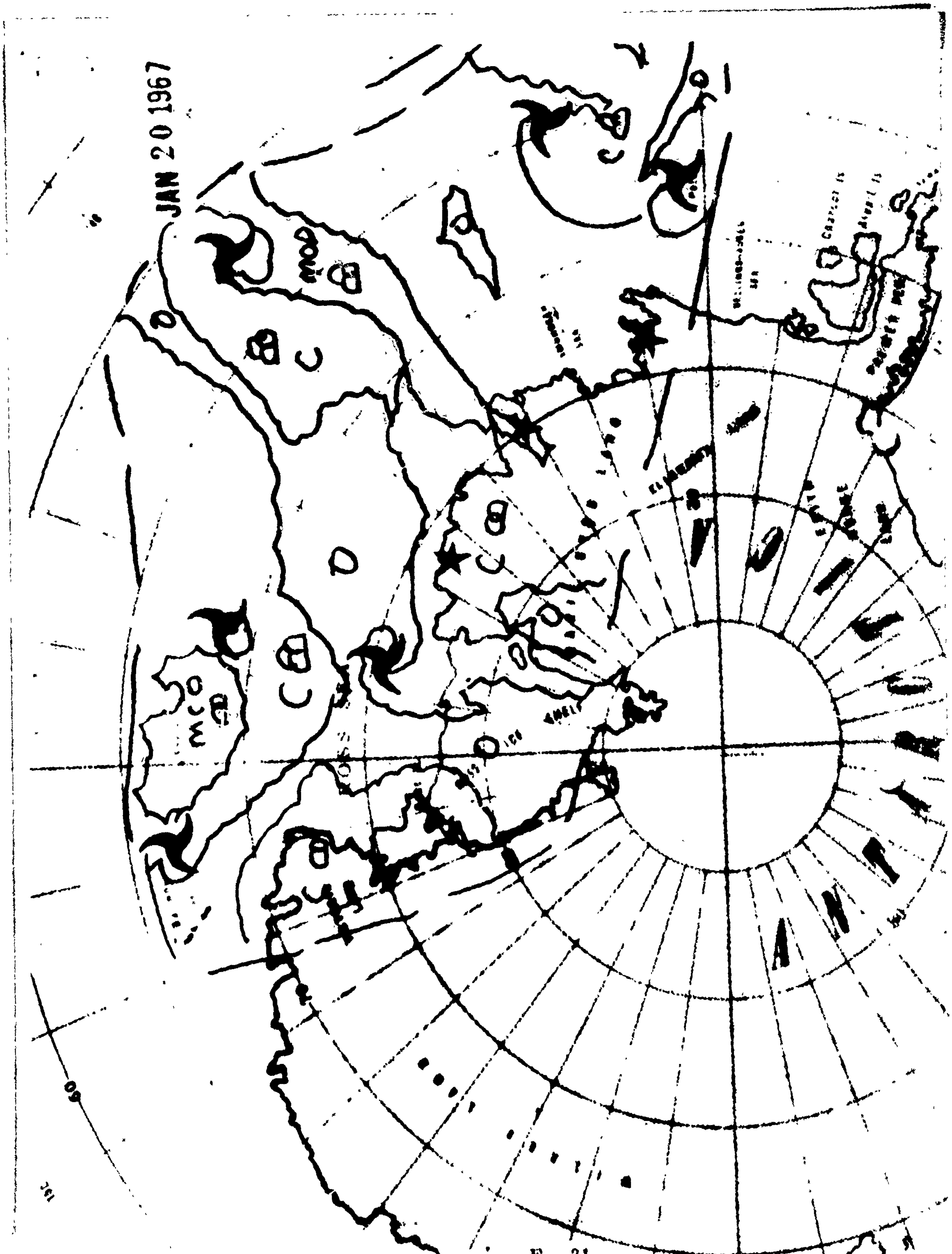
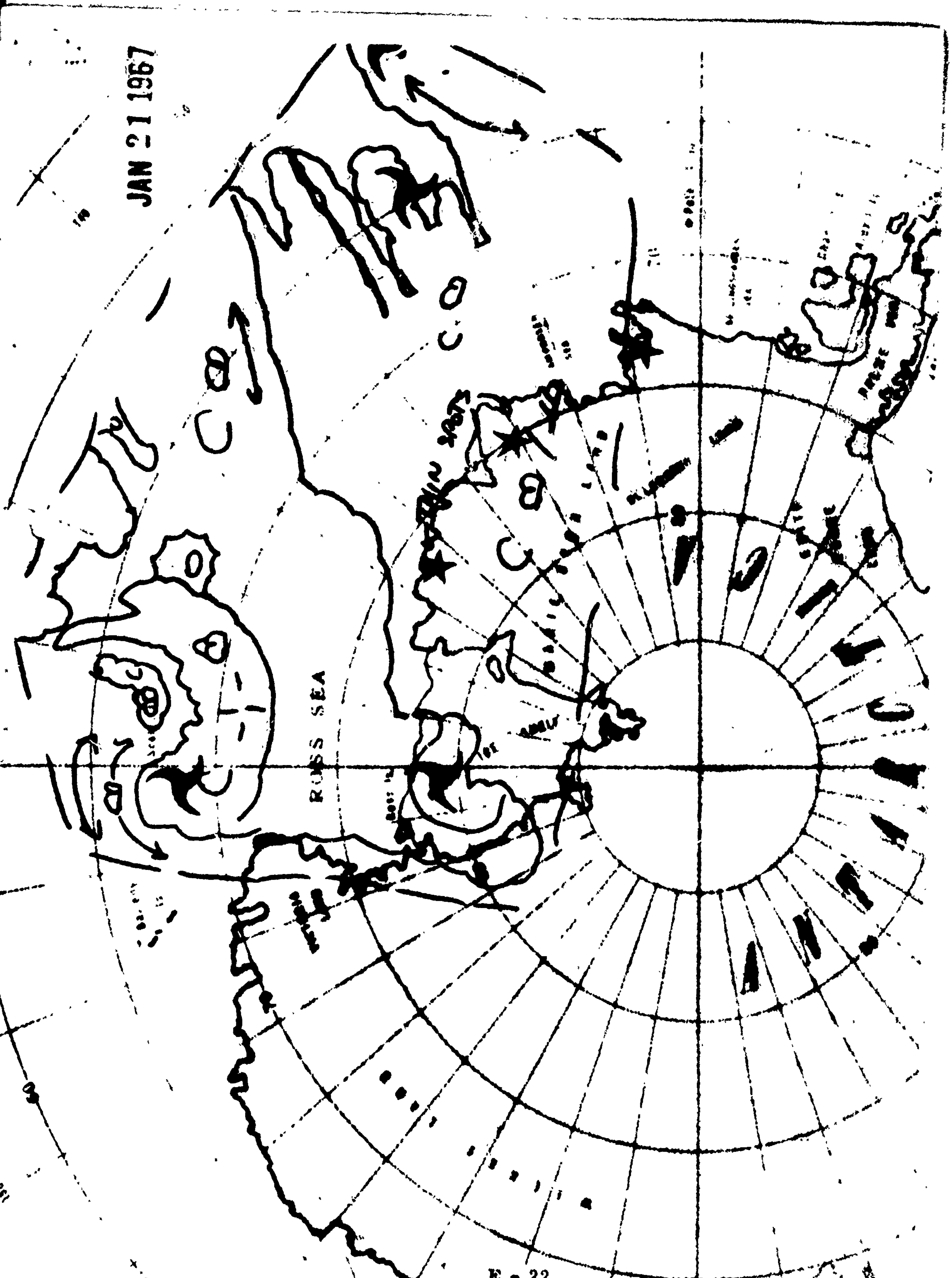

JAN 20 1967
MOD
MCO


JAN 21 1967
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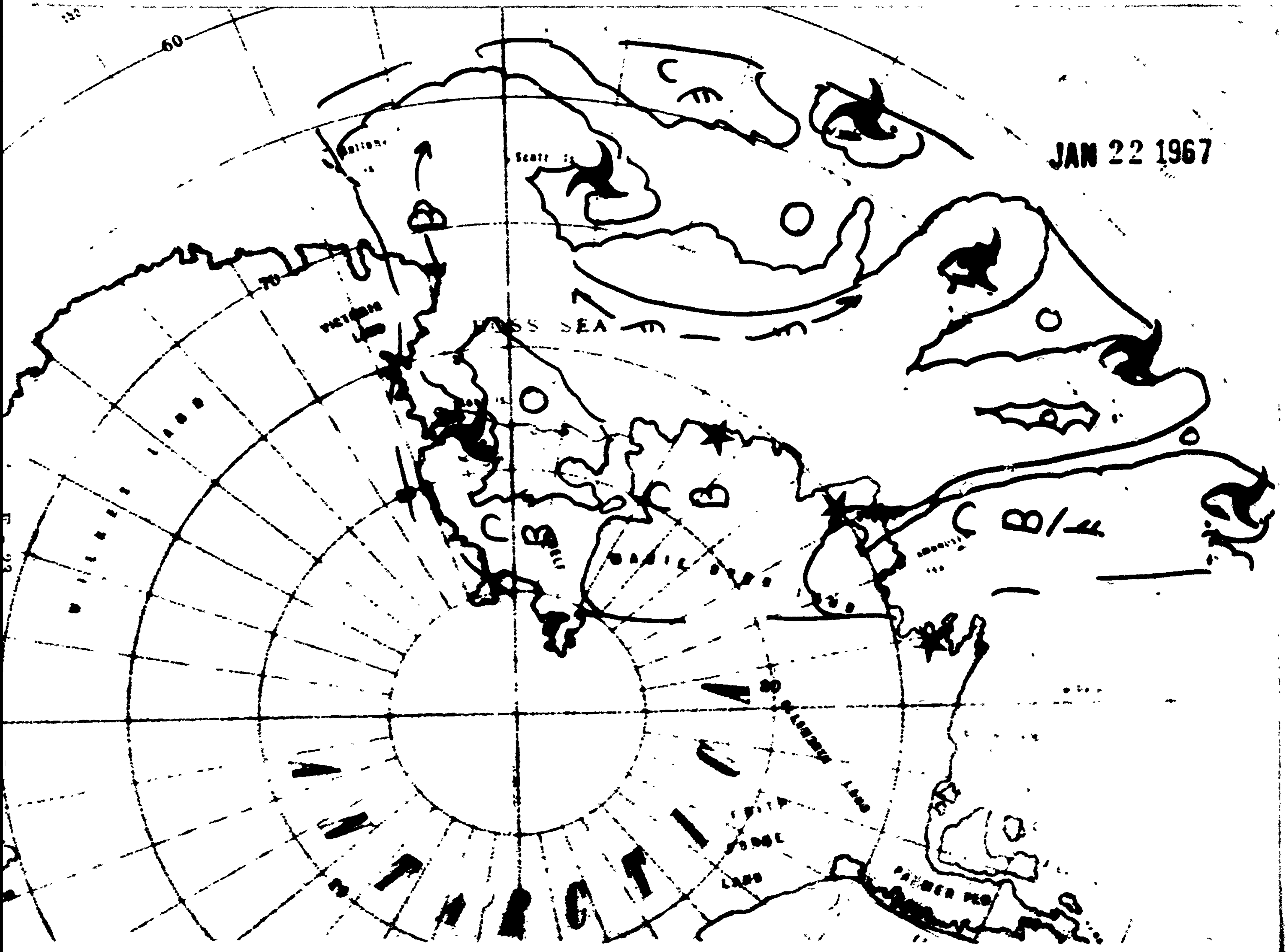
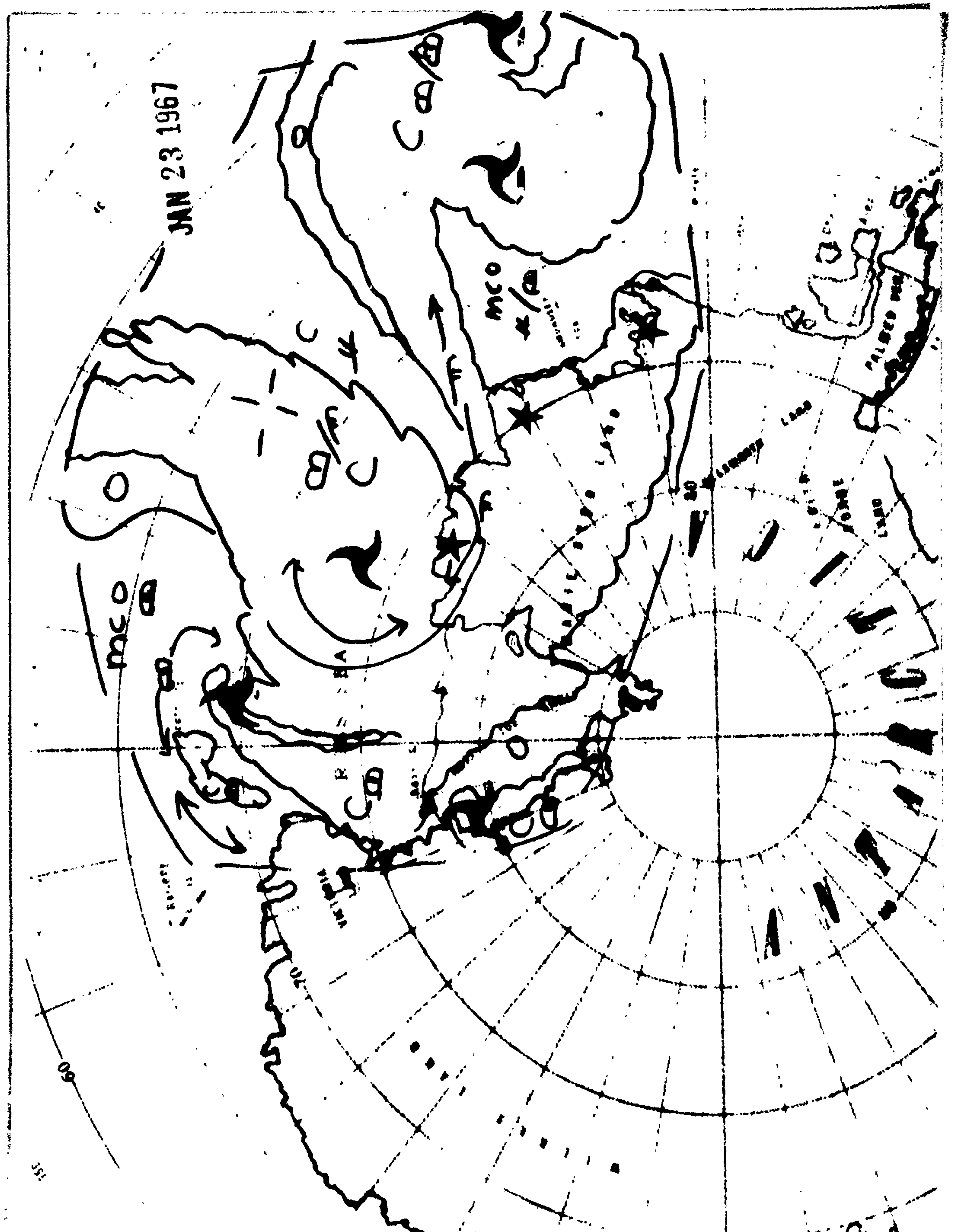
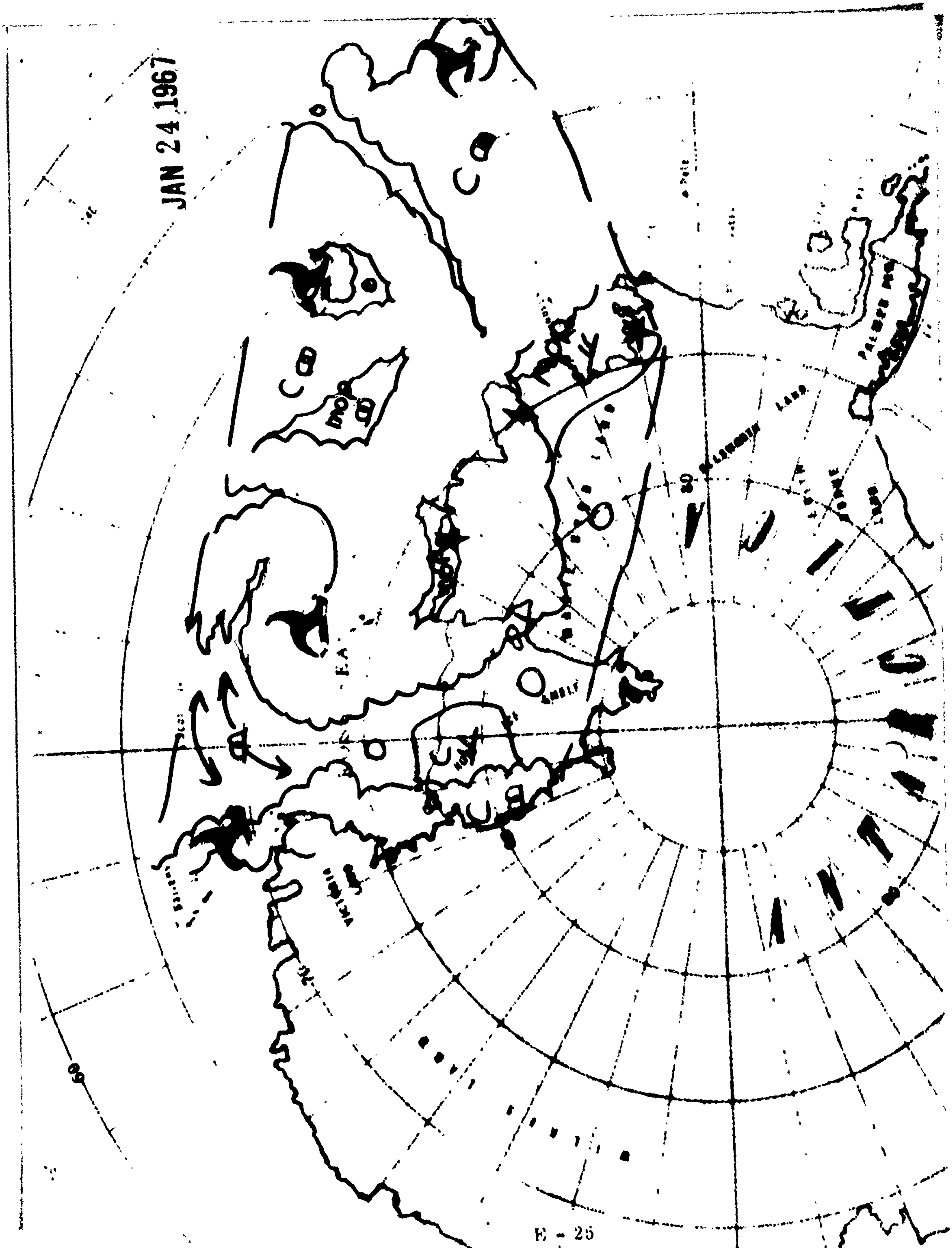

JAN 22 1967
60
70
80
Scott Is.
ROSS SEA
MARIE BYRD LAND
PALMER PEN.
ANTARCTICA


JAN 23 1967
MCO
MCO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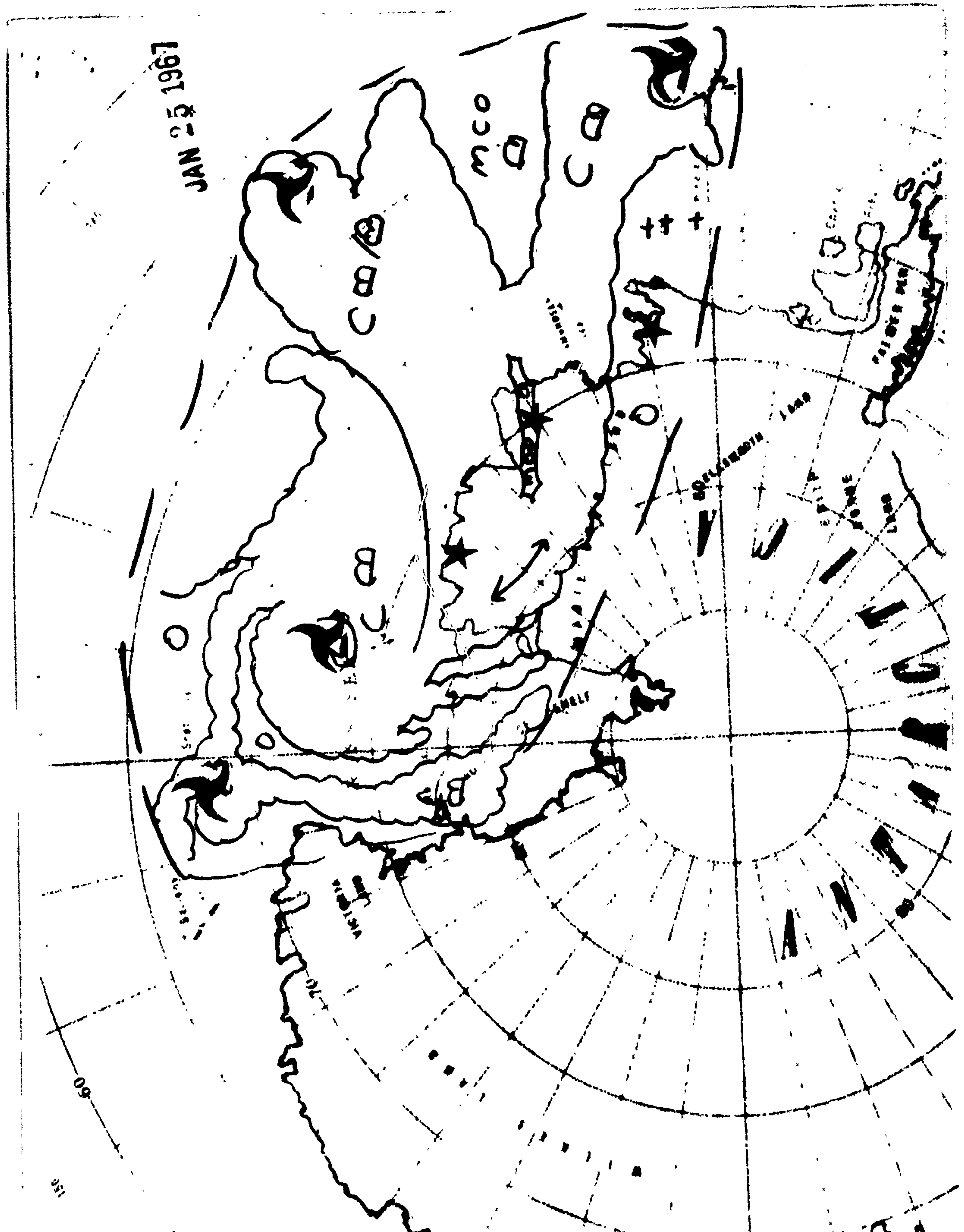
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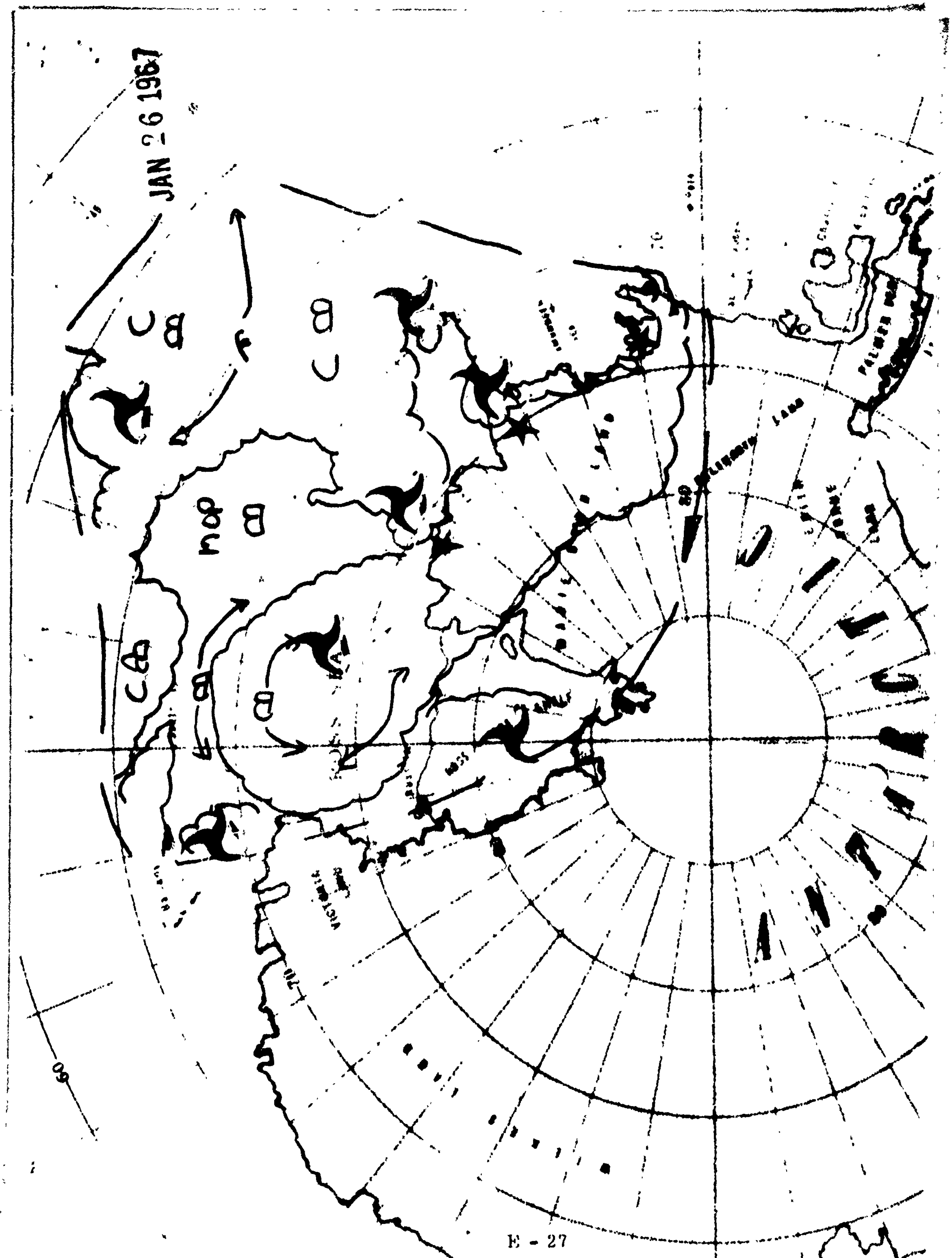
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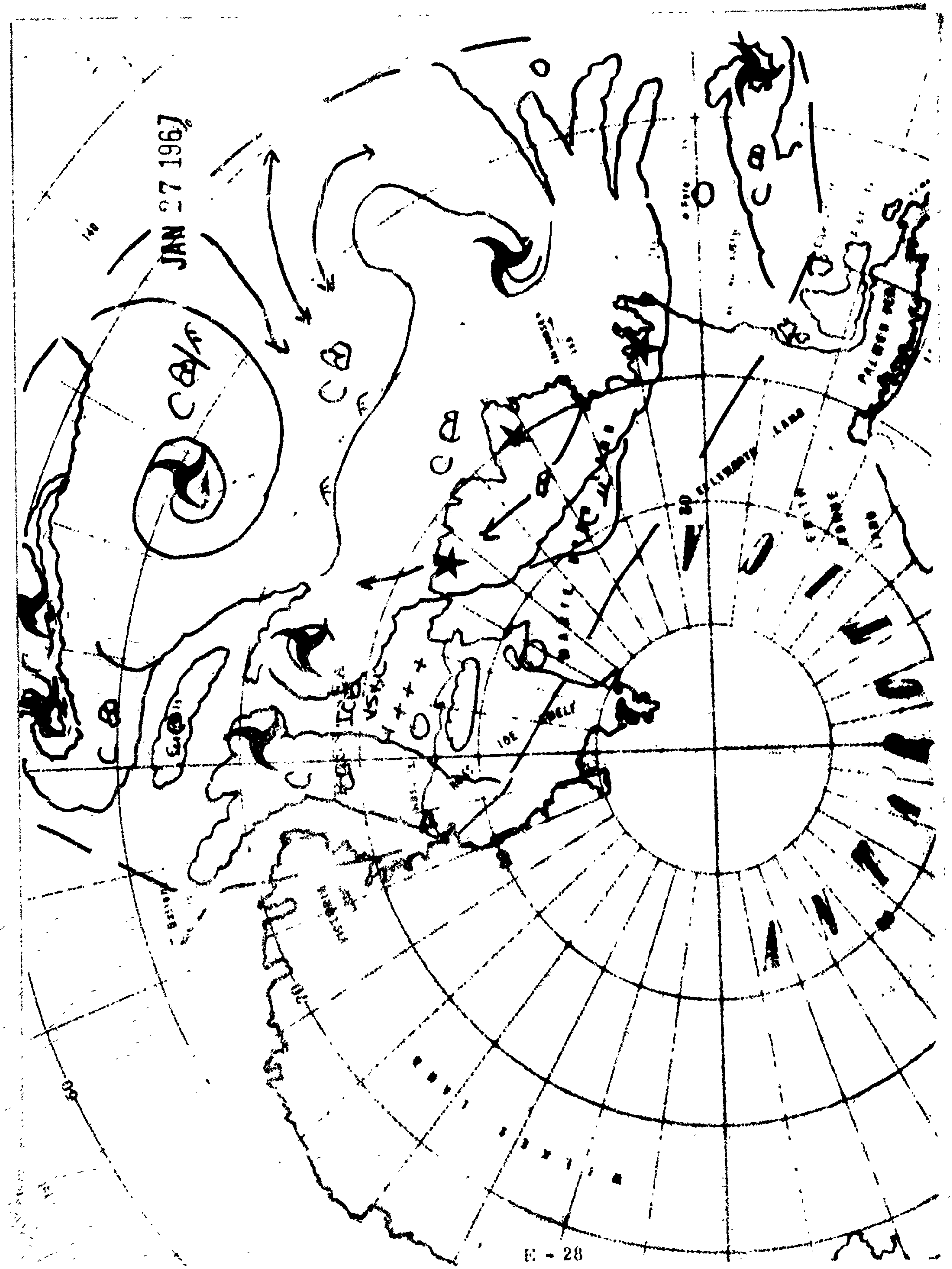
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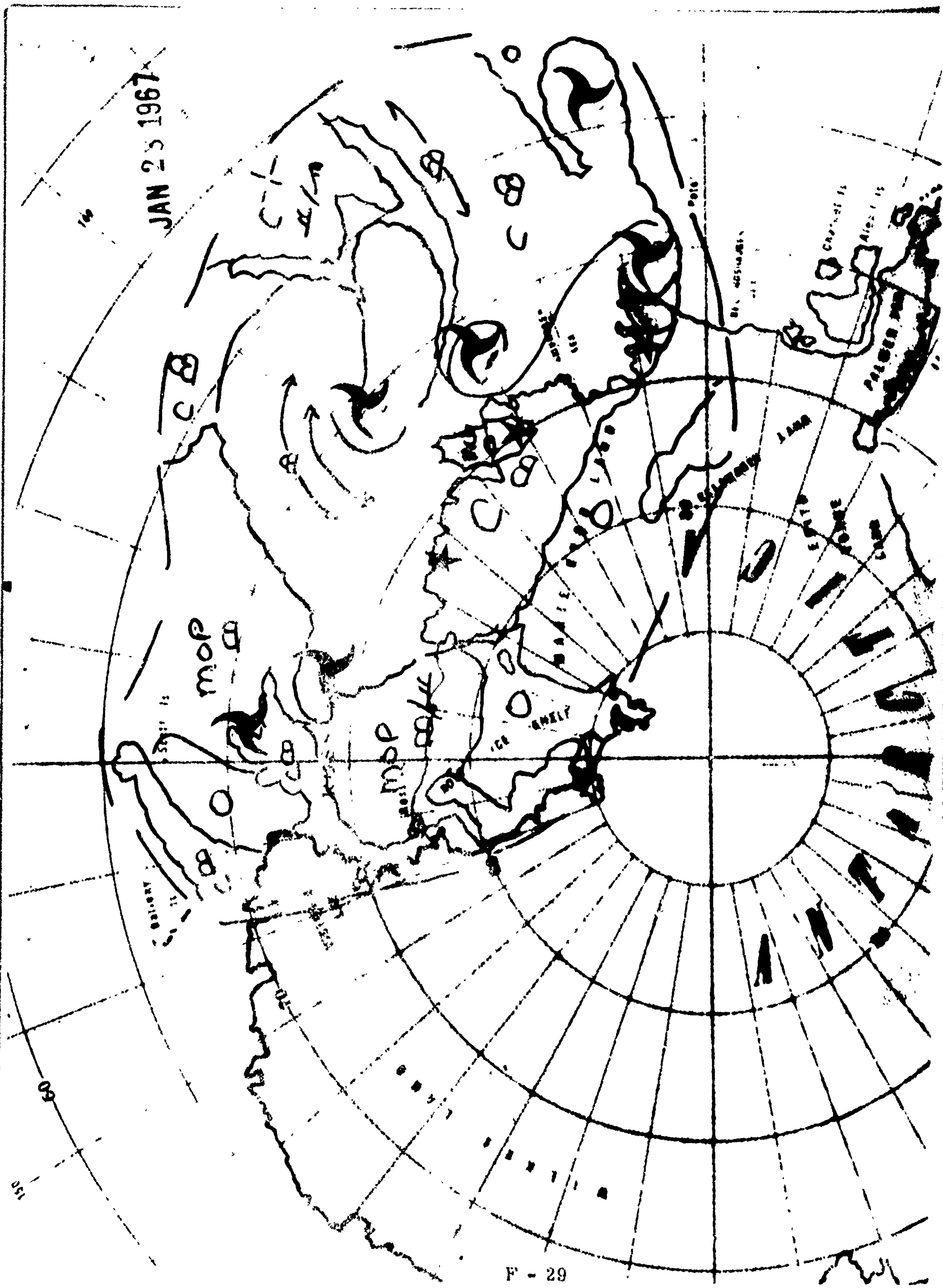

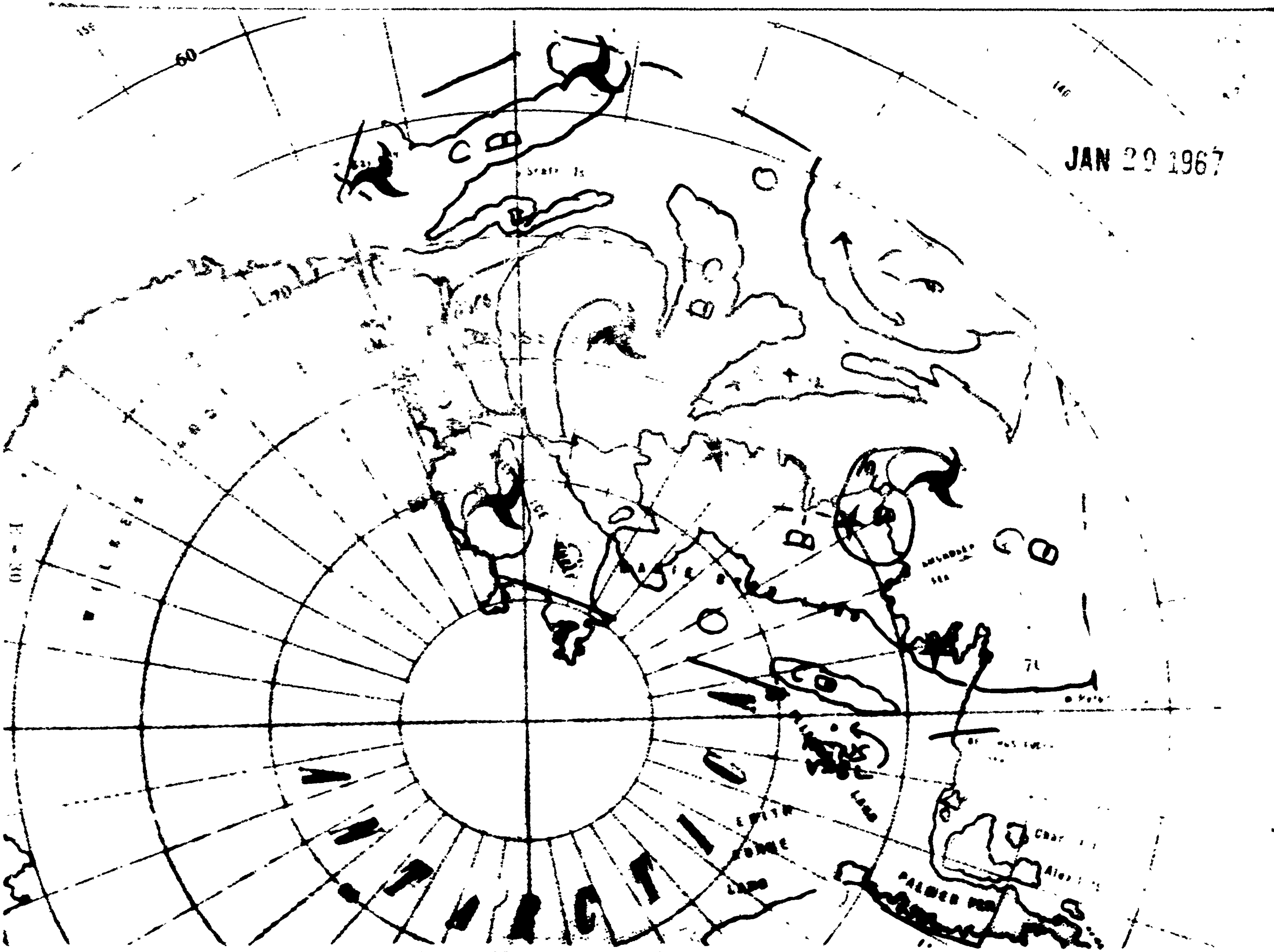
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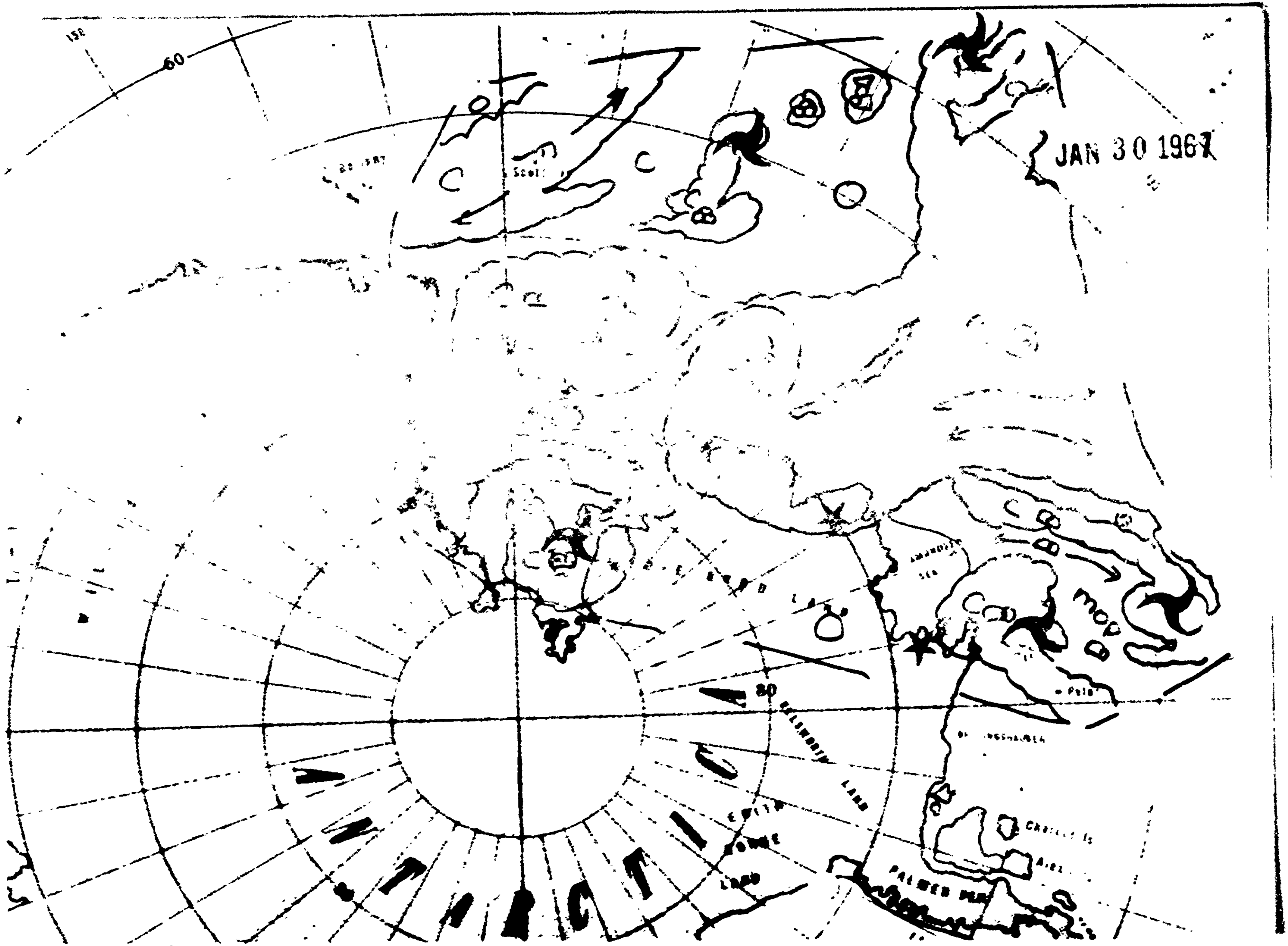
ANTARCTICA
PALMER PEN
E = 30


JAN 30 1967
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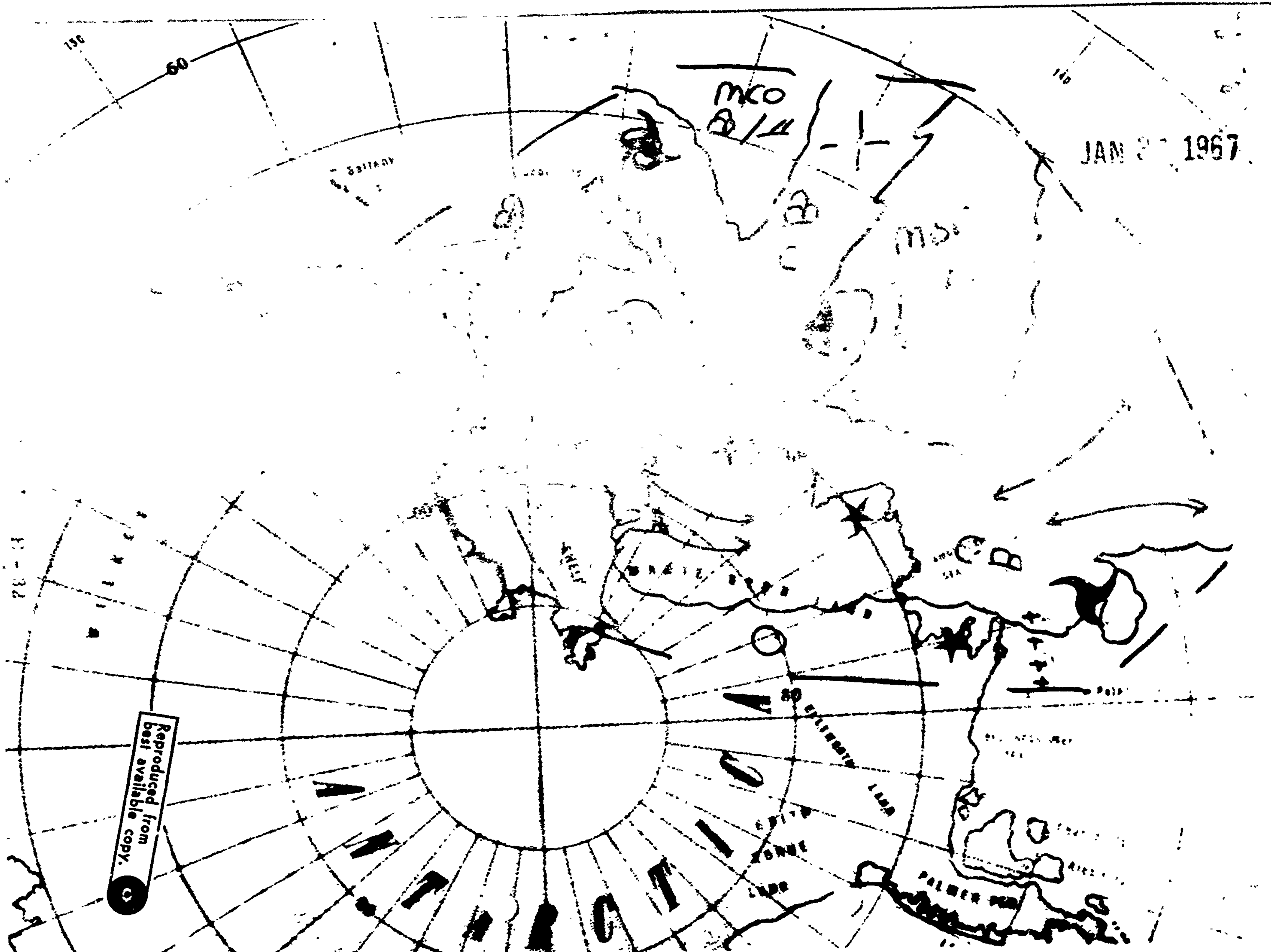
ANTARCTICA
80
ELLSWORTH LAND
EDITH RONNE LAND
PALMER PEN
AMUNDSEN SEA
C
C
C


JAN 2? 1967
mco
B/4
ANTARCTICA
ELLSWORTH LAND
PALMER PEN
SHELF
60
80